Ministry for Primary Industries
Manatū Ahu Matua

Fisheries Assessment Plenary

November 2014 – 30th Anniversary

Stock Assessments and Stock Status
Volume 1: Introductory Sections to Ray's Bream

Compiled by the Fisheries Science Group

Ministry for Primary Industries

Fisheries Science Group

Fisheries Assessment Plenary:

Stock Assessments and Stock Status

November 2014

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Fisheries Science Group
Ministry for Primary Industries
Pastoral House, 25 The Terrace
PO Box 2526, Wellington 6140
New Zealand

Requests for further copies should be directed to:
Publications Logistics Officer
Ministry for Primary Industries
PO Box 2526
WELLINGTON 6140
Email: brand@mpi.govt.nz
Telephone: 0800 00 83 33
Facsimile: 04-894 0300

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PREFACE

The publication of the May and November 2014 Fisheries Assessment Plenary Reports represent the 30th consecutive year that such reports have been produced. In recognition of this milestone, we have created a cover composed of thumbnail photographs of many of the people (rather than the fish) who have made significant contributions to our Science Working Group and Plenary processes over the years. In June 2014, we also produced a Supplement to the Plenary to celebrate 30+ years of fisheries science. The Supplement acknowledges the scientists and other players who have made it all happen and also contains a range of short articles of general interest.

Fisheries Assessment Plenary reports have represented a significant annual output of the Ministry for Primary Industries and its predecessors, the Ministry of Fisheries and the Ministry of Agriculture and Fisheries, for the last 30 years. The combined Plenary reports are now about 2000 pages long and are split into five volumes, three of which are produced in May and two in November. However, the Plenary reports only provide summaries of the available information and are in turn supported by 70-100 more detailed, readily available publications per year.

The November 2014 Fisheries Plenary Report summarises fishery, biological, stock assessment and stock status information for New Zealand’s commercial fish species or species groups in a series of Working Group or Plenary reports. Each species or species group is split into 1-10 stocks for management purposes. The November Plenary includes Working Group and Plenary summaries for species that operate on different management cycles to those summarised in the May Plenary Report. It includes Highly Migratory Species (HMS), toothfish, rock lobster, scallops and dredge oysters, covering 17 species in total.

Over time, continual improvements have been made in data acquisition, stock assessment techniques, the development of reference points to guide fisheries management decisions, and the provision of increasingly comprehensive and meaningful information from a range of audiences. This year, Working Groups have continued the effort to populate the Status of the Stocks summary tables, developed in 2009 by the Stock Assessment Methods Working Group. These tables have several uses: they provide comprehensive summary information about current stock status and the prognosis for these stocks and their associated fisheries, and they are used to evaluate fisheries performance relative to the 2008 Harvest Strategy Standard for New Zealand Fisheries and other management measures.

The Plenary reports take into account the most recent data and analyses available to Fisheries Assessment Working Groups (FAWGs) and Fisheries Assessment Plenary meetings, and also incorporate relevant analyses undertaken in previous years. Due to time and resource constraints, recent data for some stocks may not yet have been fully analysed by the FAWGs or the Plenary.

I would like to recognise and thank the large number of research providers and scientists from research organisations, academia, the seafood industry, marine amateur fisheries, environmental NGOs, Maori customary and the Ministry for Primary Industries; along with all other technical and non-technical participants in present and past FAWG and Plenary meetings for their substantial contributions to this report. My sincere thanks to each and all who have contributed.

I am pleased to endorse this document as representing the best available scientific information relevant to stock and fishery status, as at 30 November 2014.

Pamela Mace
Principal Advisor Fisheries Science
Ministry for Primary Industries

Contents

Introduction

1. This report presents the status of the fish stocks for highly migratory species, rock lobster, dredge oysters, and scallops resulting from research and stock assessments up to and including 2014.

2. The reports from the Highly Migratory Species Working Group summarise the conclusions and recommendations of the meetings of the Working Group held during 2014, and the outcomes of the Western and Central Pacific Fisheries Commission (WCPFC) and the Commission for the Conservation of Southern Bluefin Tuna (CCSBT).

3. The report from the Rock Lobster Working Group summarises the conclusions and recommendations of the meetings of the Working Group up to 2014. The decision rules were evaluated and are reported for each stock in the report.

4. The reports from the Shellfish Working Group summarise the conclusions and recommendations of the meetings of the Working Group held during 2014.

5. In all cases, consideration has been based on and limited to the best available information. The purpose has been to provide objective, independent assessments of the current state of the fish stocks.

6. Where possible, the statuses of the stocks relative to MSY-compatible targets and limits have been assessed. In many cases other management measures have also been discussed.

7. In considering Maori, traditional, recreational and other non-commercial interests, some difficulty was experienced both in terms of the data available and the intended scope of this requirement. In the absence of any more definitive guidelines, current interests and activities have been considered. In most cases, only very limited information is available on the nature and extent of non-commercial interests.

Sources of data

8. A major source of information for all assessments continues to be the fisheries statistics system. It is very important to maintain and develop that system to provide adequate and timely data for stock assessments.

9. There are issues with data reporting to the WCPFC that adds uncertainty to some of the regional highly migratory species assessments.

Other Information

10. Fisheries Assessment Reports more fully describing the data and the analyses have also been prepared. These documents are made available electronically once they have been finalised.

Glossary of Common Technical Terms

Abundance Index: A quantitative measure of fish density or abundance, usually as a time series. An abundance index can be specific to an area or to a segment of the **stock** (e.g., mature fish), or it can refer to abundance stock-wide; the index can reflect abundance in numbers or in weight (**biomass**).

Age frequency: The proportions of fish of different ages in the **stock,** or in the **catch** taken by either the commercial fishery or research fishing. This is often estimated based on a sample. Sometimes called an age composition.

Age-length key: The proportion of fish of each age in each length-group in a **catch** (or **stock**) of fish.

Age-structured stock assessment: An assessment of the **status** of a fish **stock**, that uses an assessment model to estimate how the numbers at age in the stock vary over time.

A_M*: *Age at maturity is the age at which fish, of a given sex, are considered to be reproductively mature. See a_{50}.

a_{50}: Either the age at which 50% of fish are mature (= A_M) or 50% are recruited to the fishery (=A_R)

a_{to95} : The number of ages between the age at which 50% of a stock is mature (or recruited) and the age at which 95% of the stock is mature (or recruited).

AIC: The Akaike Information Criterion is a measure of the relative quality of a statistical model for a given set of data. As such, AIC provides a means for model selection; the preferred model is the one with the minimum AIC value.

AMP: ***Adaptive Management Programme***. This involves increased **TACC's** (for a limited period, usually 5 years) in exchange for which the industry is required to provide data that will improve understanding of **stock status**. The industry is also required to collect additional information (biological data and detailed catch and effort) and perform the analyses (e.g. **CPUE** standardisation or age structure) necessary for monitoring the **stock.**

A_R* : *Age of recruitment is the age when fish are considered to be **recruited** to the fishery. In **stock assessments**, this is usually the youngest age group considered in the analyses. See a_{50}.

***B_{AV}* :** The average historic **recruited biomass**.

Bayesian analysis: an approach to stock assessment that provides estimates of uncertainty (**posterior distributions**) of the quantities of interest in the assessment. The method allows the initial uncertainty (that before the data are considered) to be described in the form of **priors**. If the data are informative, they will determine the posterior distributions; if they are uninformative, the posteriors will resemble the priors. The initial model runs are called **MPD** (mode of the posterior distribution) runs, and provide point estimates only, with no uncertainty. Final runs (Markov Chain Monte Carlo runs or **MCMCs)**, which are often very time consuming, provide both point estimates and estimates of uncertainty.

***B_{BEG}*:** The estimated **stock biomass** at the beginning of the fishing year.

***$B_{CURRENT}$*:** Current **biomass** (usually a **mid-year biomass**).

B_{YEAR}**:** Estimated or predicted **biomass** in the named year (usually a **mid-year biomass**).

Biological Reference Point (BRP): A benchmark against which the **biomass** or abundance of the **stock,** or the **fishing mortality rate** (or **exploitation rate**), or **catch** itself can be measured in order to determine **stock status**. These reference points can be **targets**, **thresholds** or **limits** depending on their intended use.

Biomass: Biomass refers to the size of the **stock** in units of weight. Often, biomass refers to only one part of the **stock** (e.g., **spawning biomass, recruited biomass,** or **vulnerable biomass, or recruited biomass** the latter two of which are essentially equivalent).

B_{MSY}**:** The average **stock biomass** that results from taking an average catch of *MSY* under various types of harvest strategies. Often expressed in terms of spawning **biomass**, but may also be expressed as **recruited** or **vulnerable biomass.**

B_o**: *Virgin biomass***. This is the theoretical **carrying capacity** of the **recruited** or **vulnerable biomass** of a fish **stock**. In some cases, it refers to the average **biomass** of the **stock** in the years before fishing started. More generally, it is the average over recent years of the biomass that theoretically would have occurred if the stock had never been fished. B_0 is often estimated from stock modelling and various percentages of it (e.g. 40% B_0) are used as **biological reference points (BRPs)** to assess the relative status of a **stock**.

Bootstrap: A statistical methodology used to quantify the uncertainty associated with estimates obtained from a **model**. The bootstrap is often based on **Monte Carlo** re-sampling of residuals from the initial **model** fit.

Bycatch: Refers to fish species, or size classes of those species, caught in association with key target species.

Carrying capacity: The average **stock** size expected in the absence of **fishing**. Even without fishing the **stock** size varies through time in response to stochastic environmental conditions. See ***B_o*****: virgin biomass**.

Catch (C): The total weight (or sometimes number) of fish caught by fishing operations.

CAY**: Current annual yield** is the one year **catch** calculated by applying a reference **fishing mortality**, F_{REF}, to an estimate of the fishable **biomass** at the beginning of the fishing year (see page 26). Also see *MAY*.

CELR forms: Catch-Effort Landing Return.

CLR forms: Catch Landing Returns.

Cohort: Those individuals of a **stock** born in the same spawning season. For annual spawners, a year's **recruitment** of new individuals to a **stock** is a single cohort or **year-class**.

Collapsed: Stocks that are below the **hard limit** are deemed to be **collapsed**.

CPUE: Catch per unit effort is the quantity of fish caught with one standard unit of fishing effort; e.g., the number of fish taken per 1000 hooks per day or the weight of fish taken per hour of trawling. CPUE is often assumed to be an **abundance index**.

Customary catch: Catch taken by tangata whenua to meet their customary needs.

CV: Coefficient of variation. A statistic commonly used to represent variability or uncertainty. For example, if a biomass estimate has a CV of 0.2 (or 20%), this means that the error in this estimate (the difference between the estimate and the true biomass) will typically be about 20% of the estimate.

Depleted: Stocks that are below the **soft limit** are deemed to be **depleted**. Stocks can become **depleted** through **overfishing**, or environmental factors, or a combination of the two.

EEZ: An **Exclusive Economic Zone** is a maritime zone over which the coastal state has sovereign rights over the exploration and use of marine resources. Usually, a state's EEZ extends to a distance of 200 nautical miles (370 km) out from its coast, except where resulting points would be closer to another country.

Equilibrium: A theoretical model result that arises when the **fishing mortality**, **exploitation pattern** and other fishery or **stock** characteristics (growth, natural mortality, **recruitment**) do not change from year to year.

Exploitable biomass: Refers to that portion of a **stock's biomass** that is available to the fishery. Also called **recruited biomass** or **vulnerable biomass**.

Exploitation pattern: The relative fraction of each age or size class of a **stock** that is vulnerable to fishing.

Exploitation rate: The proportion of the **recruited** or **vulnerable biomass** that is caught during a certain period, usually a fishing year.

***F*:** The **fishing mortality rate** is that part of the total mortality rate applying to a fish **stock** that is caused by fishing.

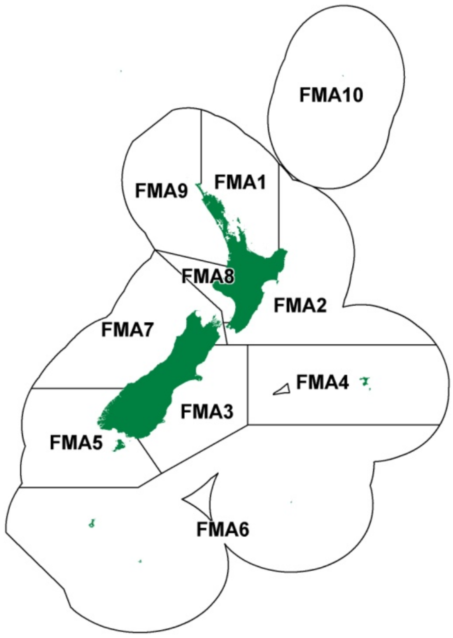
$F_{0.1}$: A biological **reference point**. It is the **fishing mortality rate** at which the increase in **equilibrium yield per recruit** in weight per unit of effort is 10% of the **yield per recruit** produced by the first unit of effort on the unexploited **stock** (i.e., the slope of the **yield per recruit** curve for the $F_{0.1}$ rate is only 1/10th of the slope of the **yield per recruit** curve at its origin).

$F_{40\%B0}$: The fishing intensity or fishing mortality associated with a biomass of 40% B_0 at equilibrium.

$F_{40\%SPR}$: The fishing intensity or fishing mortality associated with a spawning biomass per recruit (SPR) (or equivalently a spawning potential ratio) of 40% B_0 at equilibrium.

Fishing year: For most fish stocks, the fishing year runs from 1 October in one year to 30 September in the next. The second year is often used as shorthand for the split years. For example, 2005 is shorthand for 2004–05.

FMA: Fishery Management Area. The New Zealand **EEZ** is divided into 10 fisheries management units.



F_{MAX}*: A biological **reference point**. It is the **fishing mortality rate** that maximises **equilibrium yield per recruit**. ***F_{MAX} is the **fishing mortality** level that defines **growth overfishing**. In general, F_{MAX} is different from F_{MSY} (the **fishing mortality** that maximises **sustainable yield**), and is always greater than or equal to F_{MSY}, depending on the **stock-recruitment relationship**.

***F_{MEY}*:** The fishing mortality corresponding the maximum (**sustainable**) economic yield.

F_{MSY}* :** A biological **reference point**. It is the **fishing mortality rate** that, if applied constantly, would result in an average catch corresponding to the **Maximum Sustainable Yield** (MSY***) and an average biomass corresponding to B_{MSY}.

***F_{REF}*:** The level of (instantaneous) fishing mortality that, if applied every year, would, within an acceptable level of risk, maximise the average catch from the fishery.

Growth overfishing: Growth overfishing occurs when the **fishing mortality rate** is above F_{MAX}. This means that individual fish are caught before they have a chance to reach their maximum growth potential.

Hard Limit: A biomass limit below which fisheries should be considered for closure.

Harvest Strategy: For the purpose of the Harvest Strategy Standard, a harvest strategy simply specifies **target** and **limit reference points** and management actions associated with achieving the **targets** and avoiding the **limits**.

Index: Same as an **abundance index**.

Length frequency: The distribution of numbers at length from a sample of the **catch** taken by either the commercial fishery or research fishing. This is often estimated based on a sample, and sometimes called a length composition.

Length-Structured Stock Assessment: An assessment of the **status** of a fish **stock**, which uses an assessment model to estimate how the numbers at length in the stock vary over time.

Limit: a **biomass** or fishing mortality **reference point** that should be avoided with high probability. The Harvest Strategy Standard defines both **soft limit**s and **hard limit**s.

***M*:** The **natural mortality rate** is that part of the total mortality rate applying to a fish **stock** that is caused by predation and other natural events.

MALFIRM: Maximum Allowable Limit of Fishing Related Mortality.

Maturity: Refers to the ability of fish to reproduce.

Maturity ogive: A curve describing the proportion of fish of different ages or sizes that are mature.

***MAY*: Maximum average yield** is the average **maximum sustainable yield** that can be produced over the long term under a constant fishing mortality strategy, with little risk of **stock** collapse. A constant fishing mortality strategy means catching a constant percentage of the biomass present at the beginning of each fishing year. *MAY* is the long-term average annual catch when the catch each year is the *CAY*. Also see *CAY*.

MCMC: Markov Chain Monte Carlo. See **Bayesian analysis**.

***MCY*: Maximum constant yield** is the maximum sustainable yield that can be produced over the long term by taking the same catch year after year, with little risk of stock collapse.

Mid-year biomass: The biomass after half the year's catch has been taken.
Model: A conceptual and simplified idea of how the 'real world' works.

Monte Carlo Simulation: is an approach whereby the inputs that are used for a calculation are re-sampled many times assuming that the inputs follow known statistical distributions. The Monte Carlo method is used in many applications such as Bayesian analyses, parametric bootstraps and stochastic **projections**.

MPD: ***Mode of the (joint) posterior distribution*.** See **Bayesian analysis**.

***MSY*: Maximum sustainable yield** is the largest long-term average catch or yield that can be taken from a **stock** under prevailing ecological and environmental conditions. It is the maximum use that a renewable resource can sustain without impairing its renewability through natural growth and reproduction.

***MSY*-compatible reference points:** *MSY*-compatible references points include B_{MSY}, F_{MSY} and *MSY* itself, as well as analytical and conceptual **proxies** for each of these three quantities.

Otolith: One of the small bones or particles of calcareous substance in the internal ear of fish that can sometimes be used to determine their age.

Overexploitation: A situation where observed **fishing mortality** (or **exploitation**) rates exceed **targets**.

Partition: The way in which a fish stock or population is characterised, or split, in a stock assessment estimation model; for example, by sex, age and maturity.

Population: A group of fish of one species that shares common ecological and genetic features. The **stocks** defined for the purposes of **stock assessment** and management do not necessarily coincide with self-contained populations.

Population dynamics: In general, refers to the study of fish **stock** abundance and how and why it changes over time.

Posterior: a mathematical description of the uncertainty in some quantity (e.g., a biomass) estimated in a Bayesian stock assessment.

Pre-recruit: An individual that has not yet entered the fished component of the **stock** (because it is either too young or too small to be vulnerable to the fishery).

Prior: available information (often in the form of expert opinion) regarding the potential range of values of a parameter in a **Bayesian analysis**. Uninformative priors are used where there is no such information.

Production Model: A **stock model** that describes how the **stock biomass** changes from year to year (or, how **biomass** changes in **equilibrium** as a function of **fishing mortality**), but which does not keep track of the age or length frequency of the stock. The simplest production functions aggregate all of the biological characteristics of growth, **natural mortality** and reproduction into a simple, deterministic **model** using three or four parameters. Production models are primarily used in simple data situations, where total catch and effort data are available but age-structured information is either unavailable or deemed to be less reliable (although some versions of production models allow the use of age-structured data).

Productivity: Productivity is a function of the biology of a species and the environment in which it lives. It depends on growth rates, **natural mortality**, **age at maturity**, maximum average age and other relevant life history characteristics. Species with high **productivity** are able to sustain higher rates of **fishing mortality** than species with lower **productivity**. Generally, species with high productivity are more resilient and take less time to rebuild from a **depleted** state.

Projection: Predictions about trends in stock size and fishery dynamics in the future. Projections are made to address "what-if" questions of relevance to management. Short-term (1–5 years) projections are typically used in support of decision-making. Longer term projections become much more uncertain in terms of absolute quantities, because the results are strongly dependent on **recruitment,** which is very difficult to predict. For this reason, long-term projections are more useful for evaluating overall management strategies than for making short-term decisions.

Proxy: A surrogate for B_{MSY}, F_{MSY} or *MSY* that has been demonstrated to approximate one of these three metrics through theoretical or empirical studies.

***q*: Catchability** is the proportion of fish that are caught by a defined unit of fishing effort. The constant relating an **abundance index** to the true biomass (the **abundance index** is approximately equal to the true biomass multiplied by the catchability).

Quota Management Areas (QMA): QMAs are geographic areas within which fish stocks are managed in the **EEZ**.

Quota Management System (QMS): The **QMS** is the name given to the system by which the total commercial catch from all the main fish **stocks** found within New Zealand's 200 nautical mile EEZ is regulated.

Recruit: An individual that has entered the fished component of the **stock**. Fish that are not recruited are either not catchable by the gear used (e.g., because they are too small) or live in areas that are not fished.

Recruited biomass: Refers to that portion of a **stock's biomass** that is available to the fishery; also called **exploitable biomass** or **vulnerable biomass**.

Recruitment: The addition of new individuals to the fished component of a **stock**. This is determined by the size and age at which fish are first caught.

Reference Point: A benchmark against which the biomass or abundance of the **stock** or the **fishing mortality rate** (or **exploitation rate**) can be measured in order to determine its **status**. These reference points can be targets, thresholds or limits depending on their intended use.

RTWG: Marine Recreational Fisheries Technical Working Group, a sub group of the Marine Recreational Fisheries Working Group.

S_{AV}: The average historic **spawning biomass**.

Selectivity ogive: Curve describing the relative vulnerability of fish of different ages or sizes to the fishing gear used.

Soft Limit: A **biomass** limit below which the requirement for a formal, time-constrained **rebuilding plan** is triggered.

Spawning biomass: The total weight of sexually mature fish in the **stock**. This quantity depends on the abundance of **year classes**, the **exploitation** pattern, the rate of growth, both fishing and **natural mortality rates**, the onset of sexual maturity, and environmental conditions. Many types of analyses that address reproductive (spawning) potential should use a measure of production of viable eggs (e.g., fecundity). However, when such life-history information is lacking, SSB is used as a proxy. Same as **mature biomass**.

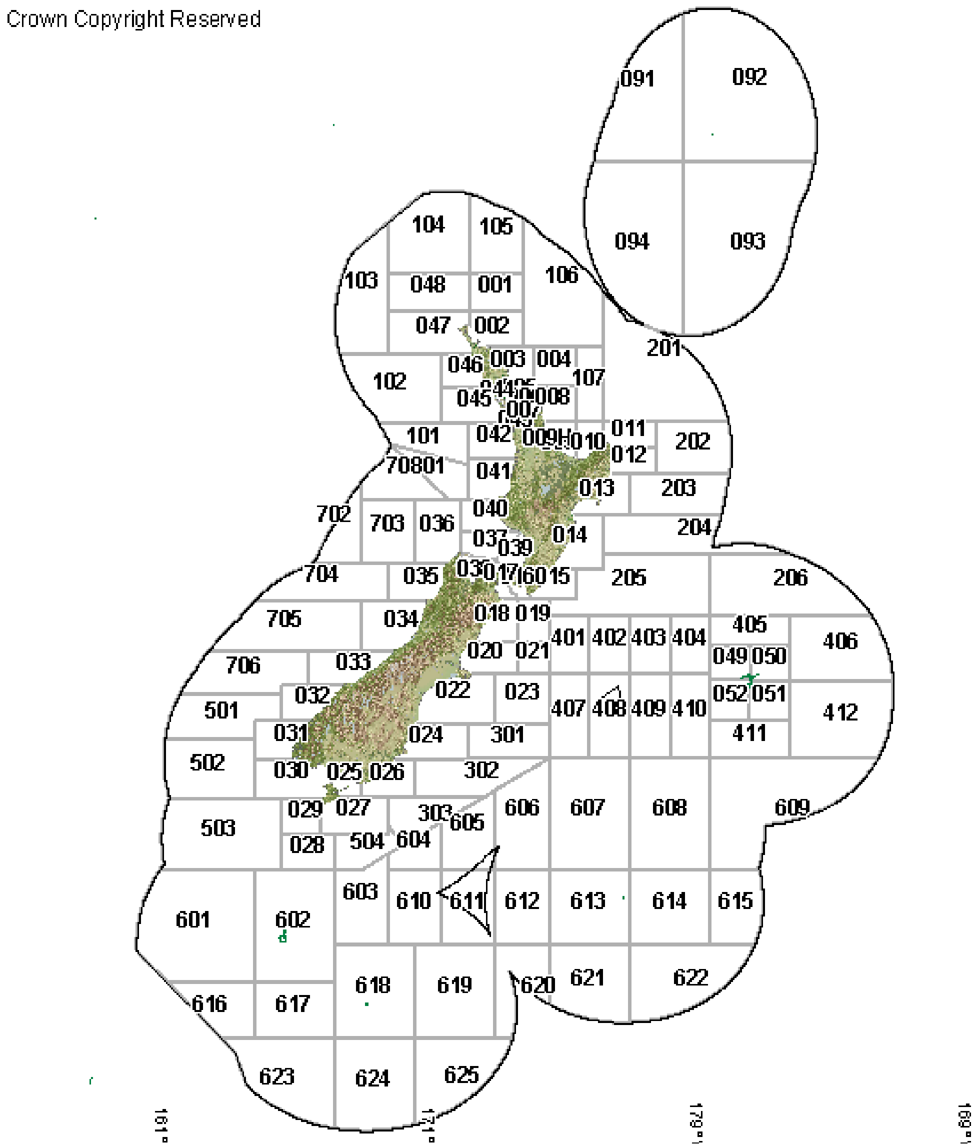
Spawning (biomass) Per Recruit or Spawning Potential Ratio (SPR): The expected lifetime contribution to the **spawning biomass** for the average recruit to the fishery. For a given exploitation pattern, rate of growth, maturity schedule and **natural mortality**, an **equilibrium** value of SPR can be calculated for any level of fishing mortality. SPR decreases monotonically with increasing fishing mortality.

Statistical area: See the map below for the official TS and EEZ statistical areas.

Stock: The term has different meanings. Under the Fisheries Act, it is defined with reference to units for the purpose of fisheries management. On the other hand, a biological stock is a population of a given species that forms a reproductive unit and spawns little if at all with other units. However, there are many uncertainties in defining spatial and temporal geographical boundaries for such biological units that are compatible with established data collection systems. For this reason, the term "**stock**" is often synonymous with an assessment / management unit, even if there is migration or mixing of some components of the assessment/management unit between areas.

Stock assessment: The application of statistical and mathematical tools to relevant data in order to obtain a quantitative understanding of the **status** of the **stock** relative to defined benchmarks or **reference points** (e.g. B_{MSY} and/or F_{MSY}).

Stock-recruitment relationship: An equation describing how the expected number of recruits to a stock varies as the **spawning biomass** changes. The most frequently used stock-recruitment relationship is the Beverton and Holt equation, in which the expected number of recruits changes very slowly at high levels of spawning biomass.



Stock status: Refers to a determination made, on the basis of **stock assessment** results, about the current condition of the **stock** and of the fishery. Stock status is often expressed relative to **biological reference points** such as B_{MSY} or B_0 or F_{MSY} or $F_{\%SPR}$. For example, the current biomass may be said to be above or below B_{MSY} or to be at some percentage of B_0. Similarly, fishing mortality may be above or below F_{MSY} or $F_{\%SPR}$.

Stock structure: (1) Refers to the geographical boundaries of the **stocks** assumed for assessment and management purposes (e.g., albacore tuna may be assumed to be comprised of two separate **stocks** in the North Pacific and South Pacific), (2) Refers to boundaries that define self-contained **stocks** in a genetic sense, (3) refers to known, inferred or assumed patterns of residence and migration for stocks that mix with one another.

Surplus production: The amount of **biomass** produced by the **stock** (through growth and **recruitment**) over and above that which is required to maintain the [total stock] **biomass** at its current level. If the catch in each year is equal to the surplus production then the biomass will not change.

Sustainability: Pertains to the ability of a fish **stock** to persist in the long-term. Because fish **populations** exhibit natural variability, it is not possible to keep all fishery and **stock**

attributes at a constant level simultaneously, thus sustainable fishing does not imply that the fishery and **stock** will persist in a constant **equilibrium** state. Because of natural variability, even if F_{MSY} could be achieved exactly each year, catches and **stock biomass** will oscillate around their average *MSY* and B_{MSY} levels, respectively. In a more general sense, sustainability refers to providing for the needs of the present generation while not compromising the ability of future generations to meet theirs.

TAC: Total Allowable Catch is the total quantity of each fishstock that can be taken by commercial, customary Maori interests, recreational fishery interests and other sources of fishing-related mortality, to ensure sustainability of that fishery in a given period, usually a year. A TAC must be set before a TACC can be set.

TACC: Total Allowable Commercial Catch is the total regulated commercial catch from a **stock** in a given time period, usually a fishing year.

Target: Generally, a **biomass** or **fishing mortality** level that management actions are designed to achieve with at least a 50% probability.

Threshold: Generally, a **biological reference point** that raises a "red flag" indicating that **biomass** has fallen below the **target**, or **fishing mortality** has increased above its **target**, to the extent that additional management action may be required in order to prevent the stock from declining further and possibly breaching the **soft limit**.

TCEPR forms: Trawl Catch-Effort Processing Return.

TLCER forms: Tuna Longline Catch-Effort Return.

$U_{40\%B0}$**:** The exploitation rate associated with a biomass of 40% B_0 at equilibrium.

von Bertalanffy equation: An equation describing how fish increase in length as they grow older. The mean length (*L*) at age *a* is

$$L = L_{\infty} (1 - e^{-k(a-to)})$$

where L_{∞} is the average length of the oldest fish, *k* is the average growth rate and t_0 is a constant.

Vulnerable biomass: Refers to that portion of a **stock's biomass** that is available to the fishery. Also called **exploitable biomass** or **recruited biomass**.

Year class (cohort): Fish in a **stock** that were born in the same year. Occasionally, a **stock** produces a very small or very large year class which can be pivotal in determining **stock** abundance in later years.

Yield: Catch expressed in terms of weight.

Yield per Recruit (YPR): The expected lifetime **yield** for the average recruit. For a given **exploitation pattern**, rate of growth, and **natural mortality**, an **equilibrium** value of YPR can be calculated for each level of **fishing mortality**. YPR analyses may play an important role in advice for management, particularly as they relate to minimum size controls.

***Z*:** Total mortality rate. The sum of **natural** and **fishing mortality rates**

Terms of Reference for Fisheries Assessment Working Groups (FAWGs) in 2014

Overall purpose

For fish stocks managed within the Quota Management System, as well as other important fisheries in which New Zealand engages:

to assess, based on scientific information, the status of fisheries and fish stocks relative to MSY-compatible reference points and other relevant indicators of stock status; to conduct projections of stock size under alternative management scenarios; and to review results from relevant research projects.

Fisheries Assessment Working Groups (FAWGs) evaluate relevant research, determine the status of fisheries and fish stocks and evaluate the consequences of alternative future management scenarios. They do not make management recommendations or decisions (this responsibility lies with MPI fisheries managers and the Minister responsible for Fisheries).

Preparatory tasks

1. Prior to the beginning of the main sessions of FAWG meetings (January to May and September to November), MPI fisheries scientists will produce a list of stocks/issues for which new stock assessments or evaluations are likely to become available prior to the next scheduled sustainability rounds. FAWG Chairs will determine the final timetables and agendas.

2. At least six months prior to the main sessions of FAWG meetings, MPI fisheries managers will alert MPI science managers and the Principal Advisor Fisheries Science to unscheduled special cases for which assessments or evaluations are urgently needed.

Technical objectives

3. To review any new research information on stock structure, productivity, abundance and related topics for each fish stock/issue under the purview of individual FAWGs.

4. To estimate appropriate MSY-compatible reference points[1] for selected fish stocks for use as reference points for determining stock status, based on the Harvest Strategy Standard for New Zealand Fisheries[2] (the Harvest Strategy Standard).

5. To conduct stock assessments or evaluations for selected fish stocks in order to determine the status of the stocks relative to MSY-compatible reference points[1] and associated limits, based on the "Guide to Biological Reference Points for Fisheries Assessment Meetings", the Harvest Strategy Standard, and relevant management reference points and performance measures set by fisheries managers.

6. In addition to determining the status of fish stocks relative to MSY-compatible reference points, and particularly where the status is unknown, FAWGs should explore the potential

[1] MSY-compatible reference points include those related to stock biomass (i.e. B_{MSY}), fishing mortality (i.e. F_{MSY}) and catch (i.e. MSY itself), as well as analytical and conceptual proxies for each of the three of these quantities.

[2] Link to the Harvest Strategy Standard: http://fs.fish.govt.nz/Page.aspx?pk=61&tk=208&se=&sd=Asc&filSC=&filAny=False&filSrc=False&filLoaded=False&filDCG=9&filDC=0&filST=&filYr=0&filAutoRun=1

for using existing data and analyses to draw conclusions about likely future trends in biomass levels and/or fishing mortality (or exploitation) rates if current catches and/or TACs/TACCs are maintained, or if fishers or fisheries managers are considering modifying them in other ways.

7. Where appropriate and practical, to conduct projections of likely future stock status using alternative fishing mortality (or exploitation) rates or catches and other relevant management actions, based on the Harvest Strategy Standard and input from the FAWG and fisheries managers.

8. For stocks that are deemed to be depleted or collapsed, to develop alternative rebuilding scenarios based on the Harvest Strategy Standard and input from the FAWG and fisheries managers.

9. For fish stocks for which new stock assessments are not conducted in the current year, to review the existing Fisheries Assessment Plenary report text on the "Status of the Stocks" in order to determine whether the latest reported stock status summary is still relevant; else to revise the evaluations of stock status based on new data or analyses, or other relevant information.

Working Group reports

10. To include in the Working Group report information on commercial, Maori customary, non-commercial and recreational interests in the stock; as well as all other mortality to that stock caused by fishing, which might need to be allowed for before setting a TAC or TACC.

11. To provide information and advice on other management considerations (e.g. area boundaries, by-catch issues, effects of fishing on habitat, other sources of mortality, and input controls such as mesh sizes and minimum legal sizes) required for specifying sustainability measures. Sections of the Working Group reports related to bycatch and other environmental effects of fishing will be reviewed by the Aquatic Environment Working Group although the relevant FAWG is encouraged to identify to the AEWG Chair any major discrepancies between these sections and their understanding of the operation of relevant fisheries.

12. To summarise the stock assessment methods and results, along with estimates of MSY-compatible references points and other metrics that may be used as benchmarks for assessing stock status.

13. To review, and update if necessary, the "Status of the Stocks" sections of the Fisheries Assessment Plenary report for all stocks under the purview of individual FAWGs (including those for which a full assessment has not been conducted in the current year) based on new data or analyses, or other relevant information.

14. For all important stocks, to complete (and/or update) the Status of Stocks template provided on pages 35-37 of the 2012 May Plenary document, following the associated instructions on pages 35-40 (or, equivalently, pages 29-35 in the November 2012 Plenary). [3]

[3] Link to the 2012 May Plenary Report: http://fs.fish.govt.nz/Page.aspx?pk=61&tk=212

15. It is desirable that full agreement amongst technical experts is achieved on the text of the FAWG reports, particularly the "Status of the Stocks" sections, noting that the AEWG will review sections on bycatch and other environmental effects of fishing. If full agreement amongst technical experts cannot be reached, the Chair will determine how this will be depicted in the FAWG report, will document the extent to which agreement or consensus was achieved, and record and attribute any residual disagreement in the meeting notes.

Working Group input to the Plenary

16. To advise the Principal Advisor Fisheries Science about stocks requiring review by the Fisheries Assessment Plenary and those stocks that are not believed to warrant review by the Plenary. The general criteria for determining which stocks should be discussed by the Plenary are that (i) the assessment is controversial and Working Group members have had difficulty reaching consensus on a base case, (ii) the assessment is the first for a particular stock or the methodology has been substantially altered since the last assessment, and (iii) new data or analyses have become available that alter the previous assessment, particularly assessments of recent or current stock status, or projections of likely future stock status. Such information could include:

- new or revised estimates of MSY-compatible reference points, recent or current biomass, productivity or yield projections;
- the development of a major trend in the catch or catch per unit effort; or
- any new studies or data that extend understanding of stock structure, fishing patterns, or non-commercial activities, and result in a substantial effect on assessments of stock status.

Membership and Protocols for all Science Working Groups

Working Group chairs

17. The Ministry will select and appoint the Chairs for Working Groups. The Chair will be an MPI fisheries scientist who is an active participant in the Working Group, providing technical input, rather than simply being a facilitator. Working Group Chairs will be responsible for:

- ensuring that Working Group participants are aware of the Terms of Reference for the Working Group, and that the Terms of Reference are adhered to by all participants;
- setting the rules of engagement, facilitating constructive questioning, and focussing on relevant issues;
- ensuring that all peer review processes are conducted in accordance with the Research and Science Information Standard for New Zealand Fisheries[4] (the Research Standard), and that research and science information is reviewed by the Working Group against the *P R I O R* principles for science information quality (page 6) and the criteria for peer review (pages 12-16) in the Standard;
- requesting and documenting the affiliations of participants at each Working Group meeting that have the potential to be, or to be perceived to be, a conflict of interest of relevance to the research under review (refer to page 15 of the Research Standard).

[4] Link to the Research Standard: http://www.fish.govt.nz/en-nz/Publications/Research+and+Science+Information+Standard.htm

Chairs are responsible for managing conflicts of interest, and ensuring that fisheries management implications do not jeopardise the objectivity of the review or result in biased interpretation of results;

- ensuring that the quality of information that is intended or likely to inform fisheries management decisions is ranked in accordance with the information ranking guidelines in the Research Standard (page 21-23), and that resulting information quality ranks are appropriately documented in Working Group reports and, where appropriate, in Status of Stock summary tables;
- striving for consensus while ensuring the transparency and integrity of research analyses, results, conclusions and final reports; and
- reporting on Working Group recommendations, conclusions and action items; and ensuring follow-up and communication with the MPI Principal Advisor Fisheries Science, relevant MPI fisheries management staff, and other key stakeholders.

Working Group members

18. Working Groups will consist of the following participants:
    - MPI fisheries science chair – required;
    - research providers – required (may be the primary researcher, or a designated substitute capable of presenting and discussing the agenda item);
    - other scientists not conducting analytical assessments to act in a peer review capacity;
    - representatives of relevant MPI fisheries management teams; and
    - any interested party who agrees to the standards of participation below.

19. Working Group participants must commit to:
    - participating appropriately in the discussion;
    - resolving issues;
    - following up on agreements and tasks;
    - maintaining confidentiality of Working Group discussions and deliberations (unless otherwise agreed in advance, and subject to the constraints of the Official Information Act);
    - adopting a constructive approach;
    - avoiding repetition of earlier deliberations, particularly where agreement has already been reached;
    - facilitating an atmosphere of honesty, openness and trust;
    - respecting the role of the Chair; and
    - listening to the views of others, and treating them with respect.

20. Participants in Working Group meetings will be expected to declare their sector affiliations and contractual relationships to the research under review, and to declare any substantial conflicts of interest related to any particular issue or scientific conclusion.

21. Working Group participants are expected to adhere to the requirements of independence, impartiality and objectivity listed under the Peer Review Criteria in the Research

Standard (pages 12-16). It is understood that Working Group participants will often be representing particular sectors and interest groups, and may be expressing the views of those groups. However, when reviewing the quality of science information, representatives are expected to step aside from their sector affiliations, and to ensure that individual and sector views do not result in bias in the science information and conclusions.

22. Participants in specific Working Groups will have access to the corresponding Science Working Group website and the Working Group papers and other information provided on the website. Although membership in Science Working Groups is open to a wide range of interested parties, access to Science Working Group websites will generally be restricted to those who have a reasonable expectation of attending at least one meeting of a given Science Working Group each year.

23. Working Group members who do not adhere to the standards of participation (paragraph 19), or who use Working Group papers and related information inappropriately (see paragraph 25), may be requested by the Chair to leave a particular meeting or to refrain from attending one or more future meetings. In more serious instances, members may be removed from the Working Group membership and denied access to the Working Group website for a specified period of time.

Working Group papers and related information

24. Working Group papers will be posted on the MPI-Fisheries website prior to meetings if they are available. As a general guide, PowerPoint presentations and draft or discussion papers should be available at least two working days before a meeting, and near-final papers should be available at least five working days before a meeting if the Working Group is expected to agree to the paper. However, it is also likely that many papers will be tabled during the meeting due to time constraints. If a paper is not available for sufficient time before the meeting, the Chair may provide for additional time for written comments from Working Group members.

25. Working Group papers are “works in progress” whose role is to facilitate the discussion of the Working Groups. They often contain preliminary results that are receiving peer review for the first time and, as such, may contain errors or preliminary analyses that will be superseded by more rigorous work. **For these reasons, no-one may release the papers or any information contained in these papers to external parties. In general, Working Group papers should never be cited.** Exceptions may be made in rare instances by obtaining permission in writing from the Principal Advisor Fisheries Science, and the authors of the paper. It is also anticipated that Working Group participants who are representing others at a particular Working Group meeting or series of such meetings may wish to communicate preliminary results to the people they are representing. Participants, along with recipients of the information, are required to exercise discretion in doing this, and to guard against preliminary results being made public.

26. From time to time, MPI commissions external reviews of particular analyses, models or issues. Terms of Reference for these reviews and the names of external reviewers may be provided to the Working Group for information or feedback. It is extremely important to the proper conduct of these reviews that all contact with the reviewers is through the Chair of the Working Group or the Principal Advisor Fisheries Science. Under no circumstances should Working Group members approach reviewers directly until after the final report of the review has been published.

Working Group meetings

27. Meetings will take place as required, generally January-April and July-November for FAWGs and throughout the year for other Working Groups (AEWG, BRAG, Marine Amateur Fisheries and Antarctic Working Groups).

28. A quorum will be reached when the Chair, the designated presenter, and three or more other technical experts are present. In the absence of a quorum, the Chair may decide to proceed as a sub-group, with outcomes being taken forward to the next meeting at which a quorum is formed.

29. The Chair is responsible for deciding, with input from the entire Working Group, but focussing primarily on the technical discussion and the views of technical expert members:

- the quality and acceptability of the information and analyses under review;
- the way forward to address any deficiencies;
- the need for any additional analyses;
- contents of Working Group reports;
- choice of base case models and sensitivity analyses to be presented; and
- the status of the stocks, or the status/performance in relation to any relevant environmental standards or targets.

30. The Chair is responsible for facilitating a consultative and collaborative discussion.

31. Working Group meetings will be run formally, with agendas pre-circulated, and formal records kept of recommendations, conclusions and action items.

32. A record of recommendations, conclusions and action items will be posted on the MPI-Fisheries website after each meeting has taken place.

33. Data upon which analyses presented to the Working Groups are based must be provided to MPI in the appropriate format and level of detail in a timely manner (i.e. the data must be available and accessible to MPI; however, data confidentiality concerns mean that such data are not necessarily available to Working Group members).

34. The outcome of each Working Group round will be evaluated, with a view to identifying opportunities to improve the Working Group process. The Terms of Reference may be updated as part of this review.

35. MPI fisheries scientists and science officers will provide administrative support to the Working Groups.

Information Quality Ranking

36. Science Working Groups are required to rank the quality of research and science information that is intended or likely to inform fisheries management decisions, in accordance with the science information quality ranking guidelines in the Research Standard (pages 21-23). Information quality rankings should be documented in Working Group reports and, where appropriate, in Status of Stock summary tables. Note that:

- Working Groups are not required to rank all research projects and analyses, but key pieces of information that are expected or likely to inform fisheries management decisions should receive a quality ranking;
- explanations substantiating the quality rankings will be included in Working Group reports. In particular, the quality shortcomings and concerns for moderate/mixed and low quality information must be documented; and
- the Chair, working with participants, will determine which pieces of information require a quality ranking. Not all information resulting from a particular research project would be expected to achieve the same quality rank, and different quality ranks may be assigned to different components, conclusions or pieces of information resulting from a particular piece of research.

Record-keeping

37. The overall responsibility for record-keeping rests with the Chair of the Working Group, and includes:

    - keeping notes on recommendations, conclusions and follow-up actions for all Working Group meetings, and to ensure that these are available to all members of the Working Group and the Principal Advisor Fisheries Science in a timely manner. If full agreement on the recommendations or conclusions cannot readily be reached amongst technical experts, then the Chair will document the extent to which agreement or consensus was achieved, and record and attribute any residual disagreement in the meeting notes; and
    - compiling a list of generic assessment issues and specific research needs for each Fishstock or species or environmental issue under the purview of the Working Group, for use in subsequent research planning processes.

Terms of Reference for the Aquatic Environment Working Group (AEWG) in 2014

Overall purpose

For all New Zealand fisheries in the New Zealand TS and EEZ as well as other important fisheries in which New Zealand engages:

to assess, based on scientific information, the effects of (and risks posed by) fishing, aquaculture, and enhancement on the aquatic environment, including:

- bycatch and unobserved mortality of protected species (e.g. seabirds and marine mammals), fish, and other marine life, and consequent impacts on populations;
- effects of bottom fisheries on benthic biodiversity, species, and habitat;
- effects on biodiversity, including genetic diversity;
- changes to ecosystem structure and function from fishing, including trophic effects; and
- effects of aquaculture and fishery enhancement on the environment and on fishing.

Where appropriate and feasible, such assessments should explore the implications of the effect, including with respect to government standards, other agreed reference points, or other relevant indicators of population or environmental status. Where possible, projections of future status under alternative management scenarios should be made.

AEWG assesses the effects of fishing or environmental status, and may evaluate the consequences of alternative future management scenarios. AEWG does not make management recommendations or decisions (this responsibility lies with MPI fisheries managers and the Minister responsible for Fisheries).

MPI also convenes a Biodiversity Research Advisory Group (BRAG) which has a similar review function to the AEWG. Projects reviewed by BRAG and AEWG have some commonalities in that they relate to aspects of the marine environment. However, the key focus of projects considered by BRAG is on marine issues related to the functionality of the marine ecosystem and its productivity, whereas projects considered by AEWG are more commonly focused on the direct effects of fishing.

Preparatory tasks

1. Prior to the beginning of AEWG meetings each year, MPI fisheries scientists will produce a list of issues for which new assessments or evaluations are likely to become available prior to the next scheduled sustainability round or decision process. AEWG Chairs will determine the final timetables and agendas.

2. The Ministry’s research planning processes should identify most information needs well in advance but, if urgent issues arise, MPI-Fisheries or standards managers will alert MPI-Fisheries science managers and the Principal Advisor Fisheries Science, at least three months prior to the required AEWG meetings to other cases for which assessments or evaluations are urgently needed.

Technical objectives

3. To review any new research information on fisheries impacts, including risks of impacts, and the relative or absolute sensitivity or susceptibility of potentially affected species, populations, habitats, and systems.

4. To estimate appropriate reference points for determining population, system, or environmental status, noting any draft or published Standards.

5. To conduct environmental assessments or evaluations for selected species, populations, habitats, or systems in order to determine their status relative to appropriate reference points and Standards, where such exist.

6. In addition to determining the status of the species, populations, habitats, and systems relative to reference points, and particularly where the status is unknown, AEWG should explore the potential for using existing data and analyses to draw conclusions about likely future trends in fishing effects or status if current fishing methods, effort, catches, and catch limits are maintained, or if fishers or fisheries managers are considering modifying them in other ways.

7. Where appropriate and practical, to conduct or request projections of likely future status using alternative management actions, based on input from AEWG, fisheries plan advisers and fisheries and standards managers, noting any draft or published Standards.

8. For species or populations deemed to be depleted or endangered, to develop ideas for alternative rebuilding scenarios to levels that are likely to ensure long-term viability based on input from AEWG, fisheries managers, noting any draft or published Standards.

9. For species, populations, habitats, or systems for which new assessments are not conducted in the current year, to review and update any existing Fisheries Assessment Plenary report text in order to determine whether the latest reported status summary is still relevant; else to revise the evaluations based on new data or analyses, or other relevant information.

Working Group input to annual Aquatic Environment and Biodiversity Review

10. To include in contributions to the Aquatic Environment and Biodiversity Review (AEBAR) summaries of information on selected issues that may relate to species, populations, habitats, or systems that may be affected by fishing. These contributions are analogous to Working Group reports from the Fisheries Assessment Working Groups.

11. To provide information and scientific advice on management considerations (e.g. area boundaries, by-catch issues, effects of fishing on habitat, other sources of mortality, and input controls such as mesh sizes and minimum legal sizes) that may be relevant for setting sustainability measures.

12. To summarise the assessment methods and results, along with estimates of relevant standards, references points, or other metrics that may be used as benchmarks or to identify risks to the aquatic environment.

13. It is desirable that full agreement among technical experts is achieved on the text of contributions to the AEBAR. If full agreement among technical experts cannot be reached, the Chair will determine how this will be depicted in the AEBAR, will document the extent to which agreement or consensus was achieved, and record and attribute any residual disagreement in the meeting notes.

14. To advise the Principal Advisor Fisheries Science, about issues of particular importance that may require review by a plenary meeting or summarising in the AEBAR, and issues that are not believed to warrant such review. The general criterion for determining which issues should be discussed by a wider group or summarised in the AEBAR is that new

data or analyses have become available that alter the previous assessment of an issue, particularly assessments of population status or projection results. Such information could include:

- New or revised estimates of environmental reference points, recent or current population status, trend, or projections;
- The development of a major trend in bycatch rates or amount;
- Any new studies or data that extend understanding of population, system, or environmental susceptibility to an effect or its recoverability, fishing patterns, or mitigation measures that have a substantial implications for a population, system, or environment or identify risks associated with fishing activity; and
- Consistent performance outside accepted reference points or Standards.

Fishery Assessment Working Groups – Membership 2014

Highly Migratory Species Working Group

Convenor: Stephen Brouwer and John Annala

Members: Peter Ballantyne, Martin De Beer, Ian Doonan, Malcolm Francis, Lynda Griggs, Bruce Hartill, Stephanie Hill, John Holdsworth, Arthur Hore, Charles Hufflet, Terese Kendrick, Adam Langley, Jeremy McKenzie, David Middleton, Tim Sippel, Alison Undorf-Lay, Dominic Vallieres.

Species: Albacore, Bigeye tuna, Blue shark, Hammerhead shark, Mako shark, Pacific bluefin tuna, Porbeagle shark, Ray's bream, Skipjack tuna, Southern bluefin tuna, Striped marlin, Swordfish, Yellowfin tuna

Rock Lobster Working Group

Convenor: Kevin Sullivan, (Geoff Tingley)

Members: Nokome Bentley, Paul Breen, N Cooper, Geoff Creighton, Charles Edwards, Jeff Forman, Gordon Halley, Vivian Haist, Doug Jones, Andy McKenzie, Alicia McKinnon, Geoff Rowling, Paul Starr, Daryl Sykes, D'Arcy Webber, Lance Wickman, Salvatore Zame

Species: Red rock lobster, Packhorse rock lobster

Shellfish Working Group

Convenor: Julie Hills

Members: Jason Baker, Michelle Beritzhoff, Richard Bian, Erin Breen, Paul Breen, Jeremy Cooper, Patrick Cordue, Martin Cryer, Alistair Dunn, Rich Ford, Allen Frazer, Dan Fu, Vivian Haist, Mark Janis, , Pamela Mace, Tom McCowan, Andrew McKenzie, Keith Michael, David Middleton, Reyn Naylor, Tracey Osborne, Marine Pomarede, Alan Riwaka, Matthew Pawley, Darryn Shaw, David Skeggs, Storm Stanley, Paul Starr, Geoff Tingley, Ian Tuck, Ellie Watts, James Williams, Graeme Wright.

Species: Dredge oysters, Scallops

QMS stocks and Ministry of Fisheries Management team with responsibility for management

INSHORE

Common name	Code	Stock
Anchovy	ANC	All
Barracouta	BAR	BAR1
Bladder kelp	KBB	All
Blue cod	BCO	All
Blue moki	MOK	All
Blue warehou	WAR	All
Bluenose	BNS	All
Butterfish	BUT	All
Cockle	COC	All
Deepwater clam	PZL	All
Dredge oyster	OYS, OYU	All
Elephantfish	ELE	All
English mackerel	EMA	EMA1, 2
Flatfish	FLA	All
Freshwater eels (NI and SI)	ANG, LFE, SFE	ALL
Frostfish	FRO	FRO1,2
Garfish	GAR	All
Gemfish	SKI	SKI1, 2
Ghost shark, dark	GSH	GSH1-3, 7-9
Greenlipped mussel	GLM	All
Grey mullet	GMU	All
Gurnard	GUR	All
Hapuka / bass	HPB	All
Horse mussel	HOR	All
Jack mackerel	JMA	JMA1
John dory	JDO	All
Kahawai	KAH	All
Kina	SUR	All
Kingfish	KIN	All
Knobbed whelk	KWH	All

Common name	Code	Stock
Leatherjacket	LEA	All
Ling	LIN	LIN1,2
Paddle crab	PAD	All
Parore	PAR	All
Paua	PAU	All
Pilchard	PIL	All
Pipi	PPI	All
Porae	POR	All
Queen scallop	QSC	All
Red cod	RCO	All
Red snapper	RSN	All
Ribaldo	RIB	RIB1, 2, 9
Rig	SPO	All
Rock lobsters (incl. PHC)	CRA	All
Scallop	SCA	All
School shark	SCH	All
Sea cucumber	SCC	All
Sea perch	SPE	SPE1, 2, 8, 9
Skate, rough and smooth	RSK, SSK	All
Snapper	SNA	All
Spiny dogfish	SPD	SPD1, 3, 7, 8
Sprat	SRR	All
Stargazer	STA	All
Surf clams	MMI,MDI, SAE,PDO, BYA	All
Tarakihi	TAR	All
Trevally	TRE	All
Trumpeter	TRU	All
Tuatua	TUA	All
Yelloweyed mullet	YEM	All

DEEPWATER

Common name	Code	Stock
Alfonsino	BYX	All
Barracouta	BAR	BAR4, 5, 7
Cardinalfish	CDL	All
Deepwater crabs: Red crab	CHC	All
King crab	KIC	All
Giant spider crab	GSC	All
English mackerel	EMA	EMA3,7
Frostfish	FRO	FRO3-9
Gemfish	SKI	SKI3, 7
Ghost shark, dark	GSH	GSH4-6
Ghost shark, pale	GSP	All
Hake	HAK	All
Hoki	HOK	All
Jack mackerel	JMA	JMA3,7
Ling	LIN	LIN3-7
Lookdown dory	LDO	All
Orange roughy	ORH	All
Oreos	SSO, BOE, OEO	All
Patagonian toothfish	PTO	All
Prawnkiller	PRK	All
Redbait	RBT	All
Ribaldo	RIB	RIB3-8
Rubyfish	RBY	All
Scampi	SCI	All
Sea perch	SPE	SPE3-7
Silver warehou	SWA	All
Southern blue whiting	SBW	All
Spiny dogfish	SPD	SPD4, 5
Squid	SQU	All
White warehou	WWA	All

HMS

Common name	Code	Stock
*Albacore tuna **	*ALB*	*All*
Bigeye tuna	BIG	All
Blue shark	BWS	All
Mako shark	MAK	All
Moonfish	MOO	All
Pacific bluefin tuna	TOR	All
Porbeagle shark	POS	All
Ray's bream	RBM	All
*Skipjack tuna **	*SKJ*	*All*
Southern bluefin tuna	STN	All
Swordfish	SWO	All
Yellowfin tuna	YFN	All

** non-QMS species*

Guide to Biological Reference Points for Fisheries Assessment Meetings

The Guide to Biological Reference Points was originally developed by a stock assessment methods Working Group in 1988, with the aim of defining commonly used terms, explaining underlying assumptions, and describing the biological reference points used in fisheries assessment meetings and associated reports. However, this document has not been substantially revised since 1992 and the methods described herein, while still used in several assessments, have been replaced with other approaches in a number of cases. Some of the latter approaches are described in the Harvest Strategy Standard for New Zealand Fisheries and the associated Operational Guidelines, and are being further developed in various Fisheries Assessment Working Groups and the current Stock Assessment Methods Working Group.

Here, methods of estimation appropriate to various circumstances are given for two levels of yield: Maximum Constant Yield (***MCY***) and Current Annual Yield (***CAY***), both of which represent different forms of maximum sustainable yield (***MSY***). The relevance of these to the setting of Total Allowable Catches (TACs) is discussed.

Definitions of *MCY* and *CAY*

The Fisheries Act 1996 defines Total Allowable Catch in terms of maximum sustainable yield (***MSY***). The definitions of the biological reference points, ***MCY*** and ***CAY***, derive from two ways of viewing ***MSY***: a static interpretation and a dynamic interpretation. The former, associated with ***MCY***, is based on the idea of taking the same catch from the fishery year after year. The latter interpretation, from which ***CAY*** is derived, recognises that fish populations fluctuate in size from year to year (for environmental and biological, as well as fishery, reasons) so that to get the best yield from a fishery it is necessary to alter the catch every year. This leads to the idea of maximum average yield (***MAY***) which is how fisheries scientists generally interpret ***MSY*** (Ricker 1975).

The definitions are:

> ***MCY*** – Maximum Constant Yield
> The maximum constant catch that is estimated to be sustainable, with an acceptable level of risk, at all probable future levels of biomass.

and

> ***CAY*** – Current Annual Yield
> The one-year catch calculated by applying a reference fishing mortality, F_{REF}, to an estimate of the fishable biomass present during the next fishing year. F_{REF} is the level of (instantaneous) fishing mortality that, if applied every year, would, within an acceptable level of risk, maximise the average catch from the fishery.

Note that ***MCY*** is dependent to a certain extent on the current state of the fish stock. If a stock is fished at the ***MCY*** level from a virgin state then over the years its biomass will fluctuate over a range of levels depending on environmental conditions, abundance of predators and prey, etc. For stock sizes within this range the ***MCY*** remains unchanged (though our estimates of it may well be refined). If the current state of the stock is below this range the ***MCY*** will be lower.

The strategy of applying a constant fishing mortality, $\boldsymbol{F_{REF}}$, from which the ***CAY*** is derived each year is an approximation to a strategy which maximises the average yield over time. For the purposes of this document the ***MAY*** is the long-term average annual catch when the catch each year is the ***CAY***. With perfect knowledge it would be possible to do better by varying the fishing mortality from year to year. Without perfect knowledge, adjusting catch levels by a ***CAY*** strategy as stock size varies is probably the best practical method of maximising average yield. Appropriate values for $\boldsymbol{F_{REF}}$ are discussed below.

What is meant by an "acceptable level of risk" for ***MCY***s and ***CAY***s is intentionally left undefined here. For most stocks our level of knowledge is inadequate to allow a meaningful quantitative assessment of risk. However, we have two qualitative sources of information on risk levels: the experience of fisheries scientists and managers throughout the world, and the results of simulation exercises such as those of Mace (1988a). Information from these sources is incorporated, as much as is possible, in the methods given below for calculating ***MCY*** and ***CAY***.

It is now well known that ***MCY*** is generally less than ***MAY*** (see, e.g., Doubleday 1976, Sissenwine 1978, Mace 1988a). This is because ***CAY*** will be larger than ***MCY*** in the majority of years. However, when fishable biomass becomes low (through overfishing, poor environmental conditions, or a combination of both), ***CAY*** will be less than ***MCY***. This is true even if the estimates of ***CAY*** and ***MCY*** are exact. The following diagram shows the relationships between ***CAY***, ***MCY*** and ***MAY***.

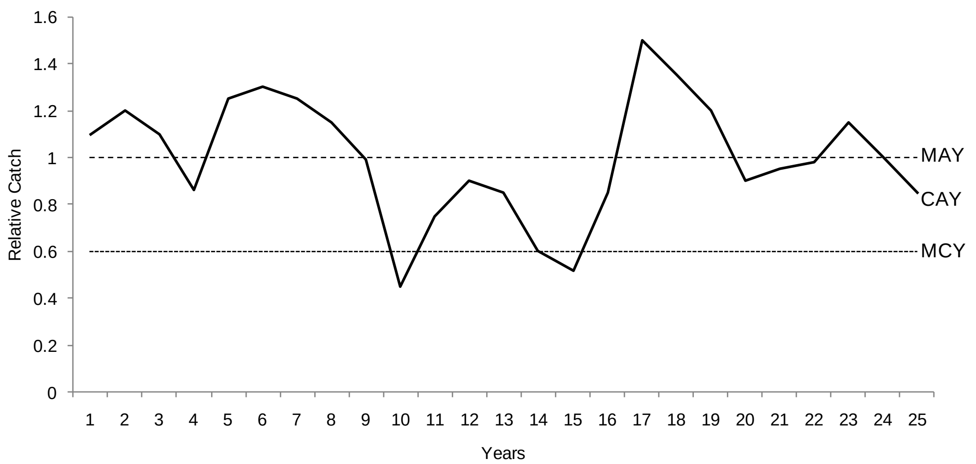


Figure 1: Relationship between *CAY*, *MCY* and *MAY*.

In this example ***CAY*** represents a constant fraction of the fishable biomass, and so (if it is estimated and applied exactly) it will track the fish population exactly. ***MAY*** is the average over time of ***CAY***. The reason ***MCY*** is less than ***MAY*** is that ***MCY*** must be low enough so that the fraction of the population removed does not constitute an unacceptable risk to the future viability of the population. With an ***MCY*** strategy, the fraction of a population that is removed by fishing increases with decreasing stock size. With a ***CAY*** strategy, the fraction removed remains constant. A constant catch strategy at a level equal to the ***MAY***, would involve a high risk at low stock sizes.

Relationship between *MCY*, *CAY*, TAC and Total Allowable Commercial Catch (TACC)

The TAC covers all mortality to a fish stock caused by human activity, whereas the TACC includes only commercial catch. ***MCY*** and ***CAY*** are reference points used to evaluate whether the current stock size can support the current TAC and/or TACC. It should not be assumed that the TAC and/or TACC will be equal to either one of these yields. There are both legal and practical reasons for this.

Legally, we are bound by the Fisheries Act 1996. In setting or varying any TACC for any quota management stock, 'the Minister shall have regard to the total allowable catch for that stock and shall allow for –

(a) The following non-commercial fishing interests in that stock, namely –
 (i) Maori customary non-commercial fishing interests; and
 (ii) Recreational interests; and
(b) All other mortality to that stock caused by fishing.

From a practical point of view it must be acknowledged that the concepts of ***MCY*** and ***CAY*** are directly applicable only in idealised management regimes. The ***MCY*** could be used in a regime where a catch level was to be set for once and for all; our system allows changes to be made if, the level is found to be too low or too high.

With a ***CAY*** strategy the yield would probably change every year. Even if there were no legal impediments to following a ***CAY*** strategy, the fishing industry's desire for stability may be a sufficient reason to make TACC changes only when the need is pressing.

Natural and Fishing Mortality

Before describing how to calculate ***MCY*** and ***CAY*** we must discuss natural and fishing mortality, which are used in these calculations. Both types of mortality are expressed as instantaneous rates (thus, over n years a total mortality Z will reduce a population of size B to size Be^{-nZ}, ignoring recruitment and growth). Units for mortalities are 1/year.

Natural mortality

Methods of estimating natural mortality, M, are reviewed by Vetter (1988). When a lack of data rules out more sophisticated methods, M may be estimated by the formula,

$$M = -\frac{log_e(p)}{A}$$

where p is the proportion of the population that reaches age A (or older) in an unexploited stock. p is often set to 0.01, when A is the "maximum age" observed. Other values for p may be chosen dependent on the fishing history of the stock. For example, in an exploited stock the maximum observed age may correspond to a value of p = 0.05, or higher. For a discussion of the method see Hoenig (1983).

Reference Fishing Mortalities

Reference fishing mortalities in widespread use include $\boldsymbol{F_{0.1}}$, $\boldsymbol{F_{MSY}}$, $\boldsymbol{F_{MAX}}$, $\boldsymbol{F_{MEY}}$, and ***M***.

The most common reference fishing mortality used in the calculation of ***CAY*** (and, in some cases, ***MCY***) is $\boldsymbol{F_{0.1}}$ (pronounced `F zero point one'). This is used as a basis for fisheries management decisions throughout the world and is widely believed to produce a high level of yield on a sustainable basis (Mace 1988b). It is estimated from a yield per recruit analysis as the level of fishing mortality at which the slope of the yield-per-recruit curve is 0.1 times the slope at $\boldsymbol{F} = 0$. If an estimate of $\boldsymbol{F_{0.1}}$ is not available an estimate of ***M*** may be substituted.

$\boldsymbol{F_{MAX}}$, the fishing mortality that produces the maximum yield per recruit. It may be too high as a target fishing mortality because it does not account for recruitment effects (e.g. recruitment declining as stock size is reduced). However, it may be a valid reference point for those fisheries that have histories of sustainable fishing at this level.

$\boldsymbol{F_{MSY}}$, the fishing mortality corresponding to the deterministic ***MSY***, is another appropriate reference point. $\boldsymbol{F_{MSY}}$ may be estimated from a surplus production model, or a combination of yield per recruit and stock recruitment models.

When economic data are available it may be possible to calculate $\boldsymbol{F_{MEY}}$ the fishing mortality corresponding to the maximum (sustainable) economic yield.

Every reference fishing mortality corresponds to an equilibrium or long-run average stock biomass. This is the biomass which the stock will tend towards or randomly fluctuate around, when the reference fishing mortality is applied constantly. The fluctuations will be caused primarily by variable recruitment. It is necessary to examine the equilibrium stock biomass corresponding to any candidate reference fishing mortality.

A reference fishing mortality which corresponds to a low stock biomass may be undesirable if the low biomass would lead to an unacceptable risk of stock collapse. For fisheries where this applies a lower reference fishing mortality may be appropriate.

Natural Variability Factor

Fish populations are naturally variable in size because of environmental variability and associated fluctuations in the abundance of predators and food. Computer simulations (e.g., Mace 1988a) have shown that, all other things being equal, the ***MCY*** for a stock is inversely related to the degree of natural variability in its abundance. That is, the higher the natural variability, the lower the ***MCY***.

The natural variability factor, ***c***, provides a way of incorporating the natural variability of a stock's biomass into the calculation of ***MCY***. It is used as a multiplying factor in method 5 below. The greater the variability in the stock, the lower is the value of ***c***. Values for ***c*** should be taken from the table below and are based on the estimated mean natural mortality rate of the stock. It is assumed that because a stock with a higher natural mortality will have fewer age-classes it will also suffer greater fluctuations in biomass. The only stocks for which the table should be deviated from are those where there is evidence that recruitment variability is unusually high or unusually low.

Natural mortality rate M	**Natural variability factor** c
< 0.05	1.0
0.05–0.15	0.9
0.16–0.25	0.8
0.26–0.35	0.7
> 0.35	0.6

Methods of Estimating *MCY*

It should be possible to estimate ***MCY*** for most fish stocks (with varying degrees of confidence). For some stocks, only conservative estimates for ***MCY*** will be obtainable (e.g., some applications of Method 4) and this should be stated. For other stocks it may be impossible to estimate ***MCY***. These stocks include situations in which: the fishery is very new; catch or effort data are unreliable; strong upwards or downwards trends in catch are not able to be explained by available data (e.g., by trawl survey data or by catch per unit effort data).

When catch data are used in estimating ***MCY*** all catches (commercial, illegal, and non-commercial) should be included if possible. If this is not possible and the excluded catch is thought to be a significant quantity, then this should be stated.

The following examples define ***MCY*** in an operational context with respect to the type, quality and quantity of data available. Knowledge about the accuracy or applicability of the data (e.g., reporting anomalies, atypical catches in anticipation of the introduction of the Quota Management System) should play a part in determining which data sets are to be included in the analysis.

As a general rule it is preferable to apply subjective judgements to input data rather than to the calculated ***MCY***s. For example, rather than saying "with the official catch statistics the ***MCY*** is ***X*** tonnes, but we think this is too high because the catch statistics are wrong" it would be better to say "we believe (for reasons given) that the official statistics are wrong and the true catches were probably such and such, and the ***MCY*** based on these catches is ***Y*** tones".

Background information on the rationale behind the following calculation methods can be found in Mace (1988a) and other scientific papers listed at the end of this document.

New fisheries

$$MCY = 0.25F_{0.1}B_0$$

where B_0 is an estimate of virgin recruited biomass. If there are insufficient data to conduct a yield per recruit analysis $F_{0.1}$ should be replaced with an estimate of natural mortality (***M***). Tables 1–3 in Mace (1988b) show that $F_{0.1}$ is usually similar to (or sometimes slightly greater than) ***M***.

It may appear that the estimate of ***MCY*** for new fisheries is overly conservative, particularly when compared to the common approximation to MSY of $\mathbf{0.5}\boldsymbol{MB_0}$ (Gulland 1971). However various authors (including Beddington & Cooke 1983; Getz *et al*. 1987; Mace 1988a) have shown that $\mathbf{0.5}\boldsymbol{MB_0}$ often overestimates ***MSY***, particularly for a constant catch strategy or when recruitment declines with stock size. Moreover it has often been observed that the development of new fisheries (or the rapid expansion of existing fisheries) occurs when stock size is unusually large, and that catches plummet as the accumulated biomass is fished down.

It is preferable to estimate ***MCY*** from a stochastic population model (Method 5), if this is possible. The simulations of Mace (1988a) and Francis (1992) indicate that the appropriate factor to multiply $\boldsymbol{F_{0.1}B_0}$ may be somewhat higher or somewhat lower than **0.25**. This depends primarily on the steepness of the assumed stock recruitment relationship (*see* Mace and Doonan 1988 for a definition of steepness).

New fisheries become developed fisheries once ***F*** has approximated or exceeded ***M*** for several successive years, depending on the lifespan of the species.

2. Developed fisheries with historic estimates of biomass

$$MCY = 0.5F_{0.1}B_{AV}$$

where $\boldsymbol{B_{AV}}$ is the average historic recruited biomass, and the fishery is believed to have been fully exploited (i.e., fishing mortality has been near the level that would produce ***MAY***). This formulation assumes that $\boldsymbol{F_{0.1}}$ approximates the average productivity of a stock.

As in the previous method an estimate of ***M*** can be substituted for $\boldsymbol{F_{0.1}}$ if estimates of $\boldsymbol{F_{0.1}}$ are not available.

3. Developed fisheries with adequate data to fit a population model

$$MCY = 2/3MSY$$

where ***MSY*** is the deterministic maximum equilibrium yield.

This reference point is slightly more conservative than that adopted by several other stock assessment agencies (e.g. ICES, CAFSAC) that use as a reference point the equilibrium yield corresponding to 2/3 of the fishing effort (fishing mortality) associated with the deterministic equilibrium ***MSY***.

If it is possible to estimate ***MSY*** then it is generally possible to estimate ***MCY*** from a stochastic population model (Method 5), which is the preferable method. The simulations of Mace (1988a) and Francis (1992) indicate that the appropriate factor to multiply ***MSY*** varies between about **0.6** and **0.9**. This depends on various parameters of which the steepness of the assumed stock recruitment relationship is the most important.

If the current biomass is less than the level required to sustain a yield of 2/3 ***MSY*** then

$$MCY = 2/3CSP$$

where ***CSP*** is the deterministic current surplus production.

4. Catch data and information about fishing effort (and/or fishing mortality), either qualitative or quantitative, without a surplus production model

$$MCY = cY_{AV}$$

where $\boldsymbol{c}$ is the natural variability factor (defined above) and $\boldsymbol{Y_{AV}}$ is the average catch over an appropriate period.

If the catch data are from a period when the stock was fully exploited (i.e. fishing mortality near the level that would produce ***MAY***), then the method should provide a good estimate of ***MCY***. In this case, $\boldsymbol{Y_{AV}}$ = ***MAY***. If the population was under-exploited the method gives a conservative estimate of ***MCY***.

Familiarity with stock demographics and the history of the fishery is necessary for the determination of an appropriate period on which to base estimates of $\boldsymbol{Y_{AV}}$. The period chosen to perform the averaging will depend on the behaviour of the fishing mortality or fishing effort time series, the prevailing management regime, the behaviour of the catch time series, and the lifespan of the species.

The period should be selected so that it contains no systematic changes in fishing mortality (or fishing effort, if this can be assumed to be proportional to fishing mortality). Note that for species such as orange roughy, where relatively static aggregations are fished, fishing mortality cannot be assumed to be proportional to effort. If catches during the period are constrained by a TACC then it is particularly important that the assumption of no systematic change in fishing mortality be adhered to. The existence of a TACC does not necessarily mean that the catch is constrained by it.

The period chosen should also contain no systematic changes in catch. If the period shows a systematic upward (or downward) trend in catches then the ***MCY*** will be under-estimated (over-estimated). It is desirable that the period be equal to at least half the exploited life span of the fish.

5. Sufficient information for a stochastic population model

This is the preferred method for estimating ***MCY*** but it is the method requiring the most information. It is the only method that allows some specification of the risk associated with an ***MCY***.

The simulations in Mace (1988a) and Breen (1989) provide examples of the type of calculations necessary for this method. A trial and error procedure can be used to find the maximum constant catch that can be taken for a given level of risk. The level of risk may be expressed as the probability of stock collapse within a specified time period. At the moment the Ministry of

Fisheries has no standards as to how stock collapse should be defined for this purpose, what time period to use, and what probability of collapse is acceptable. These will be developed as experience is gained with this method.

Methods of Estimating *CAY*

It is possible to estimate ***CAY*** only when there is adequate stock biomass data. In some instances relative stock biomass indices (e.g., catch per unit effort data) and relative fishing mortality data (e.g., effort data) may be sufficient. ***CAY*** calculated by method 1 includes non-commercial catch.

If method 2 is used and it is not possible to include a significant non-commercial catch, then this should be stated.

1. Where there is an estimate of current recruited stock biomass, ***CAY*** may be calculated from the appropriate catch equation. Which form of the catch equation should be used will depend on the way fishing mortality occurs during the year. For many fisheries it will be a reasonable approximation to assume that fishing is spread evenly throughout the year so that the Baranov catch equation is appropriate and ***CAY*** is given by

$$CAY = \frac{F_{ref}}{F_{ref} + M}(1 - e^{-(F_{ref}+M)})B_{beg}$$

Where $\boldsymbol{B_{BEG}}$ is the projected stock biomass at the beginning of the fishing year for which the ***CAY*** is to be calculated and $\boldsymbol{F_{REF}}$ is the reference fishing mortality described above.

If most of the fishing mortality occurs over a short period each year it may be better to use one of the following equations:

$$CAY = (1 - e^{-F_{ref}})B_{beg}$$

$$CAY = (1 - e^{-F_{ref}})e^{-\frac{M}{2}}B_{beg}$$

$$CAY = (1 - e^{-F_{ref}})e^{-M}B_{beg}$$

where the first equation is used when fishing occurs at the beginning of the fishing year, the second equation when fishing is in the middle of the year, and the third when fishing is at the end of the year.

It is important that the catch equation used to calculate ***CAY*** and the associated assumptions are the same as those used in any model employed to estimate stock biomass or to carry out yield per recruit analyses. Serious bias may result if this criterion is not adhered to. The assumptions and catch equations given here are by no means the only possibilities.

The risk associated with the use of a particular $\boldsymbol{F_{REF}}$ may be estimated using simulations.

2. Where information is limited but the current (possibly unknown) fishing mortality is thought to be near the optimum, there are various "status quo" methods which may be applied. Details are available in Shepherd (1991), Shepherd (1984) and Pope (1983).

FOR FURTHER INFORMATION

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Guidelines for Status of the Stocks Summary Tables

A new format for Status of the Stocks summaries was developed by the Stock Assessment Methods Working Group over the period February-April 2009. The purpose of this project was to provide more comprehensive and meaningful information for fisheries managers, stakeholders and other interested parties. Previously, Status of the Stocks summary sections had not reflected the full range of information of relevance to fisheries management contained in the earlier sections of Plenary reports, and were of variable utility for evaluating stock status and informing fisheries management decisions.

Status of the Stocks summary tables should be constructed for all stocks except those designated as "nominal"; e.g. those with administrative TACs or TACCs (generally less than 10–20 t) or those for which a commercial or non-commercial development potential has not currently been demonstrated. As of September 2012, there were a total of 288 stocks in this classification. The list of nominal stocks can be found at:
http://fs.fish.govt.nz/Doc/23085/Nominal%20Stocks%202012.pdf.ashx.

In 2012 a number of changes were made to the format for the Status of the Stocks summary tables, primarily for the purpose of implementing the science information quality rankings required by the Research and Science Information Standard for New Zealand Fisheries that was approved in April 2011 (New Zealand Ministry of Fisheries 2011a). However, these changes were only applied for Status of Stocks tables updated in 2012.

In 2013, the format was further modified to require Science Working Groups to make a determination about whether overfishing is occurring, and to further standardise and clarify the requirements for other parts of the table.

It is anticipated that the format of the Status of the Stocks tables will continue to be reviewed, standardised and modified in the future so that it remains relevant to fisheries management and other needs. New formats will be implemented each time stocks are reviewed and as time allows.

The table below provides a template for the Status of the Stocks summaries. The text following the template gives guidance on the contents of most of the fields in the table. Superscript numbers refer to the corresponding numbered paragraph in the following text. Light blue text provides an example of how the table might be completed.

STATUS OF THE STOCKS TEMPLATE[1]

Stock Structure Assumptions[2]

<insert relevant text>

- **Fishstock name**[3]

Stock Status	
Year of Most Recent Assessment	2013
Assessment Runs Presented	Base case model only
Reference Points[4]	Target: 40% B_0 Soft Limit: 20% B_0 Hard Limit: 10% B_0 Overfishing threshold: F_{MSY}
Status in relation to Target[5,6]	B_{2013} was estimated to be 50% B_0; Very Likely (> 90%) to be at or above the target
Status in relation to Limits[5,6]	B_{2013} is Very Unlikely (< 10%) to be below both the soft and

	hard limits
Status in relation to Overfishing[6,7]	The fishing intensity in 2012 was Very Unlikely (< 10%) to be above the overfishing threshold [or, Overfishing is Very Unlikely (<10%) to be occurring]
Historical Stock Status Trajectory and Current Status[8]	
	<insert relevant graphs>

Fishery and Stock Trends	
Recent Trend in Biomass or Proxy[9]	Biomass reached its lowest point in 2001 and has since consistently increased
Recent Trend in Fishing Intensity or Proxy[6,9]	Fishing intensity reached a peak of F=0.54 in 1999, subsequently declining to less than F=0.2 since 2006
Other Abundance Indices[10]	-
Trends in Other Relevant Indicators or Variables[11]	Recent recruitment (2005–2012) is estimated to be near the long-term average

Projections and Prognosis	
Stock Projections or Prognosis[12]	Biomass is expected to stay steady over the next 5 years assuming current (2011–12) catch levels
Probability of Current Catch or TACC causing Biomass to remain below or to decline below Limits[6,13]	Soft Limit: Very Unlikely (< 10%) Hard Limit: Very Unlikely (< 10%)
Probability of Current Catch or TACC causing Overfishing to continue or to commence[6,13]	Very Unlikely (< 10%)

Assessment Methodology and Evaluation		
Assessment Type[14]	Level 1 - Full quantitative stock assessment	
Assessment Method	Age-structured CASAL model with Bayesian estimation of posterior distributions	
Assessment Dates	Latest assessment: 2012	Next assessment: 2014
Overall assessment quality rank[15]	1 – High Quality	
Main data inputs (rank)[15]	- Research time series of abundance indices (trawl and acoustic surveys). - Proportions at age data from the commercial fisheries and trawl surveys. - Estimates of biological parameters. - New information since the 2011 assessment included two trawl surveys, an acoustic survey, and updated catch and catch-at-age data	1 – High Quality 1 – High Quality 1 – High Quality 1 – High Quality
Data not used (rank)[16]	Commercial CPUE	3 – Low Quality: does not track stock biomass
Changes to Model Structure and Assumptions[17]	None since the 2009 assessment	

Major Sources of Uncertainty	The base case model deals with the lack of older fish in commercial catches and surveys by estimating natural mortality age which results in older fish suffering high natural mortality. However, there is no evidence to validate this outside the model estimates. Aside from natural mortality, other major sources of uncertainty include stock structure and migration patterns, stock-recruit steepness and natal fidelity assumptions. Uncertainty about the size of recent year classes affects the reliability of stock projections.

Qualifying Comments[18]
The impact of the current young age structure of the population on spawning success is unknown

Fishery Interactions[19]
Main bycatch species are hake, ling, silver warehou and spiny dogfish, with lesser bycatches of ghost sharks, white warehou, sea perch and stargazers. Incidental interactions and associated mortalities are noted for New Zealand fur seals and seabirds. Low productivity species taken in the fishery include basking sharks and deepsea skates.

Guidance on preparing the Status of the Stocks summary tables

1. Everything included in the Status of the Stocks summary table should be derived from earlier sections in the Working Group or Plenary report. No new information should be presented in the summary that was not encompassed in the main text of the Working Group or Plenary report.

Stock Structure Assumptions

2. The current assumptions regarding the stock structure and distribution of the stocks being reported on should be briefly summarised. Where the assessed stock distribution differs from the relevant QMA fishstock(s), an explanation must be provided of how the stock relates to the QMA fishstock(s) it includes.

Stock Status

3. One Status of the Stocks summary table should be completed for each assessed stock or stock complex.

4. Management targets for each stock will be established by fisheries managers. Where management targets have not been established, it is suggested that an interim target of 40% B_0, or a related B_{MSY}-compatible target (or $F_{40\%}$ or a related target) should be assumed. In most cases, the soft and hard limits should be set at the default levels specified in the Harvest Strategy Standard (20% B_0 for the soft limit and 10% B_0 for the hard limit). Similarly, the overfishing threshold should be set at F_{MSY}, or a related F_{MSY}-compatible threshold. Overfishing thresholds can be expressed in terms of fishing mortality, exploitation rates, or other valid measures of fishing intensity. When agreed reference points have not been established, stock status may be reported against interim reference points.

5. Reporting stock status against reference points requires Working Group agreement on the model run to use as a base case for the assessment. The preference, wherever possible, is to report on the best estimates from a single base case, or to make a single statement that covers the results from a range of cases. In general, ranges or confidence intervals should not be included in the table. Only where more than one equally plausible model run exists, and agreement cannot be reached on a single base case, should multiple

runs be reported. This should still be done simply and concisely (e.g. median results only).

6. Where probabilities are used in qualifying a statement regarding the status of the stock in relation to target, limit, or threshold reference levels, the following probability categories and associated verbal descriptions are to be used (IPCC, 2007):

Probability	Description
> 99 %	Virtually Certain
> 90 %	Very Likely
> 60 %	Likely
40 - 60 %	About as Likely as Not
< 40 %	Unlikely
< 10 %	Very Unlikely
< 1 %	Exceptionally Unlikely

Probability categories and associated descriptions should relate to the probability of being "at or above" biomass targets (or "at or below" fishing intensity targets if these are used), below biomass limits, and above overfishing thresholds. Note, however, that the descriptions and associated probabilities adopted need not correspond exactly to model outputs; rather they should be superimposed with the Working Group's belief about the extent to which the model fully specifies the probabilities. This is particularly relevant for the "Virtually Certain" and "Exceptionally Unlikely" categories, which should be used sparingly.

7. The status in relation to overfishing can be expressed in terms of an explicit overfishing threshold, or it can simply be a statement about the Working Group's belief, based on the evidence at hand, about the likelihood that overfishing is occurring (based on, for example, a stock abundance index exhibiting a pronounced recent increase or decline). The probability rankings in the IPCC (2007) table above should be used. Overfishing thresholds can be considered in terms of fishing mortality rates, exploitation rates, or other valid measures of fishing intensity.

Historical Stock Status Trajectory and Current Status

8. This heading should be changed to reflect the graphs that are available to illustrate trends in biomass or fishing intensity (or proxies) and the current stock or fishery status.

Recent Fishery and Stock Trends

9. Recent stock or fishery trends should be reported in terms of stock size and fishing intensity (or proxies for these), respectively. For full quantitative (Level 1) assessments, median results should be used when reporting biomass. Observed trends should be reported using descriptors such as increasing, decreasing, stable, or fluctuating without trend. Where it is considered relevant and important to fisheries management, mention could be made of whether the indicator is moving towards or away from a target, limit, threshold, or long term average.

10. Other Abundance Indices: This section is primarily intended for reporting of trends where a Level 2 (partial quantitative) evaluation has been conducted, and appropriate abundance indices (such as standardised CPUE or survey biomass) are available.

11. Other Relevant Indicators or Variables: This section is primarily intended for reporting of trends where only a Level 3 (qualitative) evaluation has been conducted. Potentially useful indicators might include trends in mean size, size or age composition, or

recruitment indices. Catch trends vs TACC may be relevant here, provided these are qualified when other factors are known to have influenced the trends.

Projections and Prognosis

12. These sections should be used to report available information on likely future trends in biomass or fishing intensity or related variables under current (or a range of) catch levels over a period of approximately 3–5 years following the last year in the assessment. If a longer period is used, this must be stated.

13. When reporting probabilities of current catches or TACC levels causing declines below limits, the probability rankings in the IPCC (2007) table above should be used. Results should be reported separately (i.e. split into two rows) if the catch and TACC differ appreciably, resulting in differing conclusions for each level of removals, with the level of each specified. The timeframe for the projections should be approximately 3–5 years following the last year in the assessment unless a longer period of time is required by fisheries managers.

Assessment Methodology and Evaluation

14. Assessment type: the envisaged Assessment Levels are:

1 – Full Quantitative Stock assessment: There is a reliable index of abundance and an assessment indicating status in relation to targets and limits.
2 – Partial Quantitative Stock Assessment: An evaluation of agreed abundance indices (e.g. standardised CPUE) or other appropriate fishery indicators (e.g. estimates of *F* (*Z*) based on catch-at-age) is available. Indices of abundance or fishing intensity have not been used in a full quantitative stock assessment to estimate stock or fishery status in relation to reference points.
3 – Qualitative Evaluation: A fishery characterisation with evaluation of fishery trends (e.g. catch, effort,unstandardised CPUE, or length-frequency information) has been conducted but there is no agreed index of abundance.
4 – Low information evaluation: There are only data on catch and TACC, with no other fishery indicators.

Management Procedure (MP) updates should be presented in a separate table. In years when an actual assessment is conducted for stocks under MPs, the MP update table should be preceded by a Status of the Stocks summary table.

Table content will vary for these different assessment levels.

Ranking of Science Information Quality

15. The Research and Science Information Standard for New Zealand Fisheries (2011a) specifies (pages 21–23) that the Ministry will implement processes that rank the quality of research and science information used in support of fisheries management decisions. The quality ranking system is:

1 – High Quality: information that has been subjected to rigorous science quality assurance and peer review processes as required by this Standard, and substantially meets the key principles for science information quality. Such information can confidently be accorded a high weight in fisheries management decisions. An explanation is not required in the table for high quality information.

2 – Medium or Mixed Quality: information that has been subjected to some level of peer review against the requirements of the Standard and has been found to have some shortcomings with regard to the key principles for science information quality, but is

still useful for informing management decisions. Such information should be accompanied by a description of its shortcomings.

3 – Low Quality: information that has been subjected to peer review against the requirements of the Standard but has substantially failed to meet the key principles for science information quality. Such information should be accompanied by a description of its shortcomings and should not be used to inform management decisions.

One of the key purposes of the science information quality ranking system is to inform fisheries managers and stakeholders of those datasets, analyses or models that are of such poor quality that they should not be used to make fisheries management decisions (i.e. those ranked as "3"). Most other datasets, analyses or models that have been subjected to peer review or staged technical guidance in the Ministry's Science Working Group processes and have been accepted by these processes should be given the highest score (ranked as "1"). Uncertainty, which is inherent in all fisheries science outputs, should not by itself be used as a reason to score down a research output, unless it has not been properly considered or analysed, or if the uncertainty is so large as to render the results and conclusions meaningless (in which case, the Working Group should consider rejecting the output altogether). A ranking of 2 (medium or mixed quality) should only be used where there has been limited or inadequate peer review or the Working Group has mixed views on the validity of the outputs, but believes they are nevertheless of some use to fisheries management.

16. In most cases, the "Data not used" row can be filled in with "N/A"; it is primarily useful for specifying particular datasets that the Working Group considered but did not use in an assessment because they were of low quality and should not be used to inform fisheries management decisions.

Changes to Model Assumptions and Structure

17. The primary purpose of this section is to briefly identify only the most significant model changes that directly resulted in significant changes to results on the status of the stock concerned, and to briefly indicate the main effect of these changes. Details on model changes should be left in the main text of the report.

Qualifying Comments

18. The purpose of the "Qualifying Comments" section is to provide for any necessary explanations to avoid misinterpretation of information presented in the sections above. This section may also be used for brief further explanation considered important to understanding the status of the stock.

Fishery Interactions

19. The "Fishery Interactions" section should be used to simply list QMS by-catch species, non-QMS by-catch species and protected / endangered species interactions.

FOR FURTHER INFORMATION

IPCC (2007) Climate Change 2007: Synthesis Report. Contribution of Working Groups I, II and III to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change. [Core Writing Team, Pachauri, R K; Reisinger, A (eds.)]. IPCC, Geneva, Switzerland, 104 p.

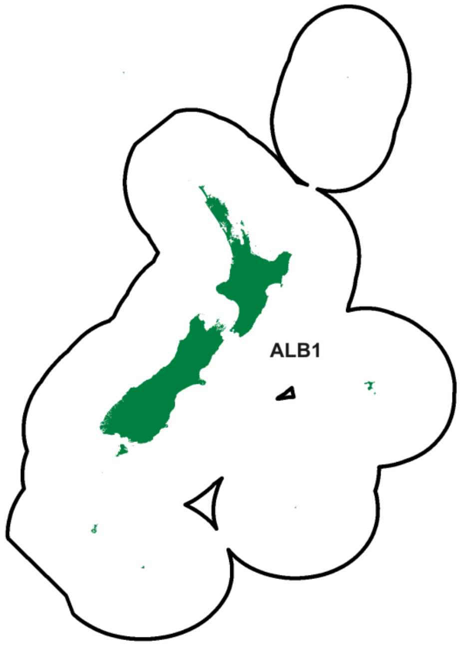
New Zealand Ministry of Fisheries (2008) Harvest Strategy Standard for New Zealand fisheries. 25 p. Available at http://fs.fish.govt.nz/Page.aspx?pk=61&tk=208&se=&sd=Asc&filSC=&filAny=False&filSrc=False&filLoaded=False&filDCG=9&filDC=0&filST=&filYr=0&filAutoRun=1.

New Zealand Ministry of Fisheries (2011a) Research and Science Information Standard for New Zealand Fisheries. 31 p. Available at http://www.fish.govt.nz/en-nz/Publications/Research+and+Science+Information+Standard.htm.

New Zealand Ministry of Fisheries (2011b) Operational Guidelines for New Zealand's Harvest Strategy Standard Revision 1. 78 p. Available at http://fs.fish.govt.nz/Doc/22847/Operational_Guidelines_for_HSS_rev_1_Jun_2011.pdf.ashx.

ALBACORE (ALB)

(*Thunnus alalunga)*
Ahipataha



1. FISHERY SUMMARY

Albacore is currently outside the Quota Management System.

Management of albacore stock throughout the South Pacific is the responsibility of the Western and Central Pacific Fisheries Commission (WCPFC). Under this regional convention New Zealand is responsible for ensuring that the management measures applied within New Zealand fisheries waters are compatible with those of the Commission.

At its seventh annual meeting in 2011 the WCPFC passed a Conservation and Management Measure (CMM) (this is a binding measure that all parties must abide by) CMM2010-05 relating to conservation and management measures for South Pacific albacore tuna. Key aspects of this CMM are repeated below:

1. "Commission Members, Cooperating Non-Members, and participating Territories (CCMs) shall not increase the number of their fishing vessels actively fishing for South Pacific albacore in the Convention Area south of 20°S above current (2005) levels or recent historical (2000–2004) levels".

2. The provisions of paragraph 1 shall not prejudice the legitimate rights and obligations under international law of small island developing State and Territory CCMs in the Convention Area for whom South Pacific albacore is an important component of the domestic tuna fishery in waters under their national jurisdiction, and who may wish to pursue a responsible level of development of their fisheries for South Pacific albacore.

3. CCMs that actively fish for South Pacific albacore in the Convention Area south of the equator shall cooperate to ensure the long-term sustainability and economic viability of

the fishery for South Pacific albacore, including cooperation and collaboration on research to reduce uncertainty with regard to the status of this stock.

4. This measure will be reviewed annually on the basis of advice from the Scientific Committee on South Pacific albacore."

1.1 Commercial fisheries

The South Pacific albacore catch in 2013 (84698 t) was the second highest on record. Catches from within New Zealand fisheries waters in 2013 were about 4% of the South Pacific albacore catch.

In New Zealand, albacore form the basis of a summer troll fishery, primarily on the west coasts of the North and South Islands. In 2013 about 90% of the albacore catch was taken by troll. Albacore are also caught throughout the year by longline. Total annual landings between 2000 and 2013 ranged between 2092 and 6744 t (Table 1). Figure 1 shows the historical landings and fishing effort for albacore stocks.

The earliest known commercial catch of tuna (species unknown but probably skipjack tuna) was by trolling and was landed in Auckland in the year ending March 1943. Regular commercial catches of tuna, however, were not reported until 1961. These catches are summarised in Table 1 (species unknown but primarily albacore and skipjack and possibly included southern bluefin and yellowfin tuna). Prior to 1973 the albacore troll fishery was centred off the North Island (Bay of Plenty to Napier and New Plymouth) with the first commercial catches off Greymouth and Westport (54% of the total catch) in 1973. The expansion of albacore trolling to the west coast of the South Island immediately followed experimental fishing by the *W. J. Scott*, which showed substantial quantities of albacore off the Hokitika Canyon and albacore as far south as Doubtful Sound. Tuna longlining was not established as a fishing method in the domestic industry until the early 1990s.

Table 1: Reported total New Zealand landings (t) and landings (t) from the South Pacific Ocean (SPO) of albacore tuna from 1972 to 2013.

Year	NZ fisheries waters	SPO	Year	NZ fisheries waters	SPO	Year	NZ fisheries waters	SPO
1972	240	39 521	1987	1 236	25 052	2002	5 566	73 240
1973	432	47 330	1988	672	37 867	2003	6 744	62 477
1974	898	34 049	1989	4 884	49 076	2004	4 459	61 871
1975	646	23 600	1990	3 011	36 062	2005	3 459	62 566
1976	25	29 082	1991	2 450	35 600	2006	2 542	62 444
1977	621	38 740	1992	3 481	38 668	2007	2 092	58 591
1978	1 686	34 676	1993	3 327	35 438	2008	3 720	62 740
1979	814	27 076	1994	5 255	42 318	2009	2 216	82 901
1980	1 468	32 541	1995	6 159	38 467	2010	2 292	88 942
1981	2 085	34 784	1996	6 320	34 359	2011	3 205	66 476
1982	2 434	30 788	1997	3 628	39 490	2012	2 990	87 752
1983	720	25 092	1998	6 525	50 371	2013	3 142	84 698
1984	2 534	24 704	1999	3 903	39 614			
1985	2 941	32 328	2000	4 428	47 338			
1986	2 044	36 590	2001	5 349	58 344			

Source: LFRR and MHR WCPFC Yearbook 2012 Anon (2013).

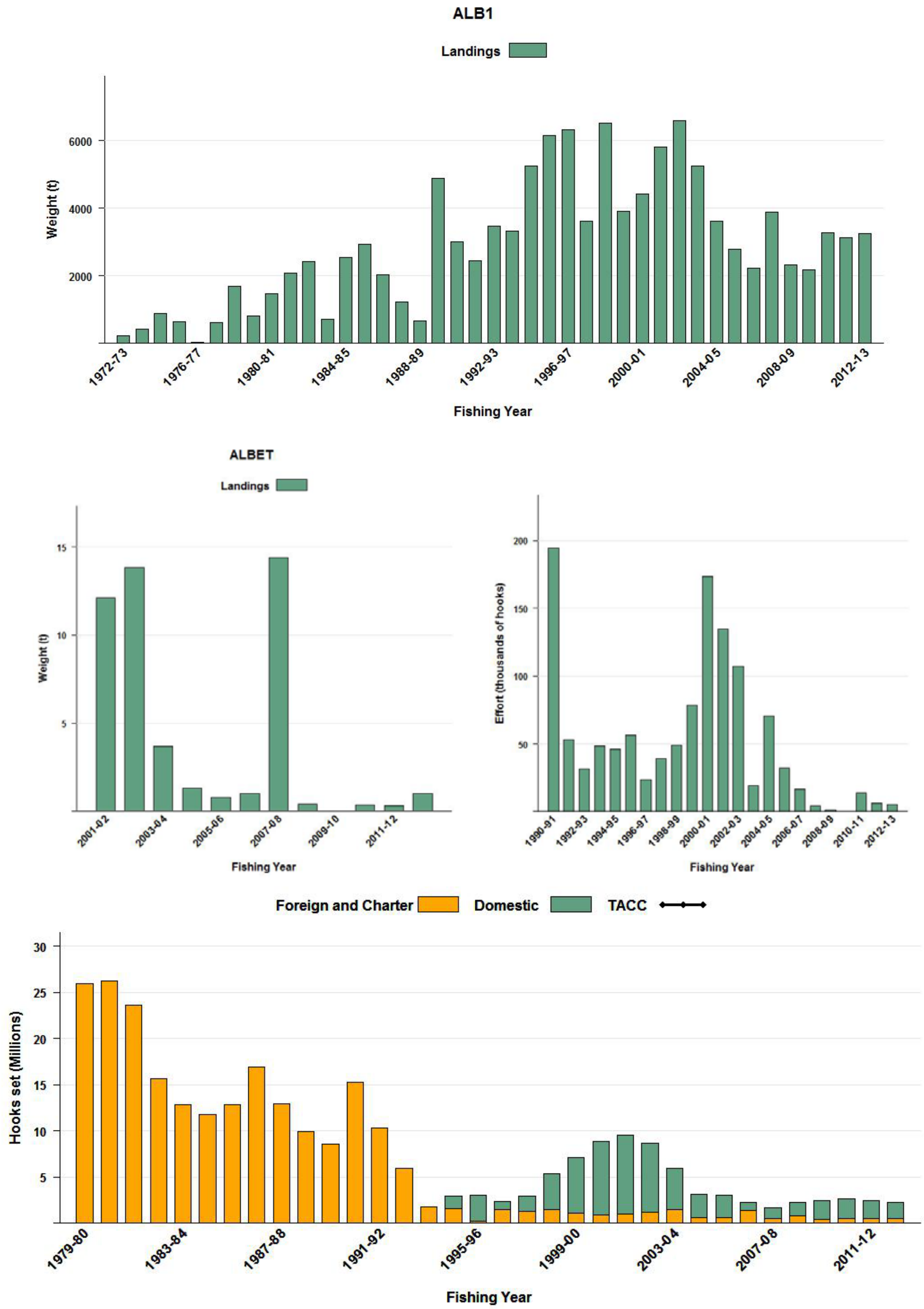


Figure 1: [Top and middle] Albacore catch from 1972–73 to 2012–13 within New Zealand waters (ALB 1) and 2001–02 to 2012–13 on the high seas (ALB ET). [Bottom] Fishing effort (number of hooks set) for all high seas New Zealand flagged surface longline vessels, from 1990–91 to 2012–13.

The New Zealand albacore fishery, especially the troll fishery, has been characterised by periodic poor years that have been linked to poor weather or colder than average summer seasons. Despite this variability, domestic albacore landings have steadily increased since the start of commercial fishing in the 1960s. The average catch in the 1960s (19 t) increased in the 1970s to 705 t, in the

1980s to 2256 t, and in the 1990s averaged 4571 t but both catch and effort have declined almost continuously through the 2000s from a high in 2002–03.

Most albacore troll fishery catches are in the first and second quarters of the calendar year, with the fourth quarter important in some years (1994 to 1996). Most of the troll fishery catch comes from FMA 7 off the west coast of the South Island although FMA 1, FMA 2, FMA 8 and FMA 9 have substantial catches in some years. High seas troll catches have been infrequent and a minor component (maximum catch of 42.2 t in 1991) of the New Zealand fishery over the 1991 to 2011 period. Albacore are caught by longline throughout the year as a bycatch on sets targeting bigeye and southern bluefin tuna. Most of the longline albacore catch is reported from FMA 1 and FMA 2 with lesser amounts caught in FMA 9. While albacore are caught regularly by longline in high seas areas, New Zealand effort and therefore catches are small.

Small catches of albacore are occasionally reported using pole-and-line and hand line gear. Pole-and-line catches of albacore have been reported from FMA 1, FMA 2, FMA 5, FMA 7, and FMA 9. Hand line catches have been reported from FMA 1 and FMA 7.

The majority of albacore caught in New Zealand waters is by troll fishing, which accounts for 55% of the overall effort in the surface lining fisheries (troll, surface longline, pole & line) and 91% of the albacore catch. In the surface longline fisheries, 66% of fishing effort is directed at bigeye tuna, while for all surface lining fisheries combined, 58% of fishing effort is directed at albacore (Figure 2). Albacore makes up 32% of the catch in the surface longline fisheries and 69% of the catch for all surface lining fisheries combined (Figure 3).

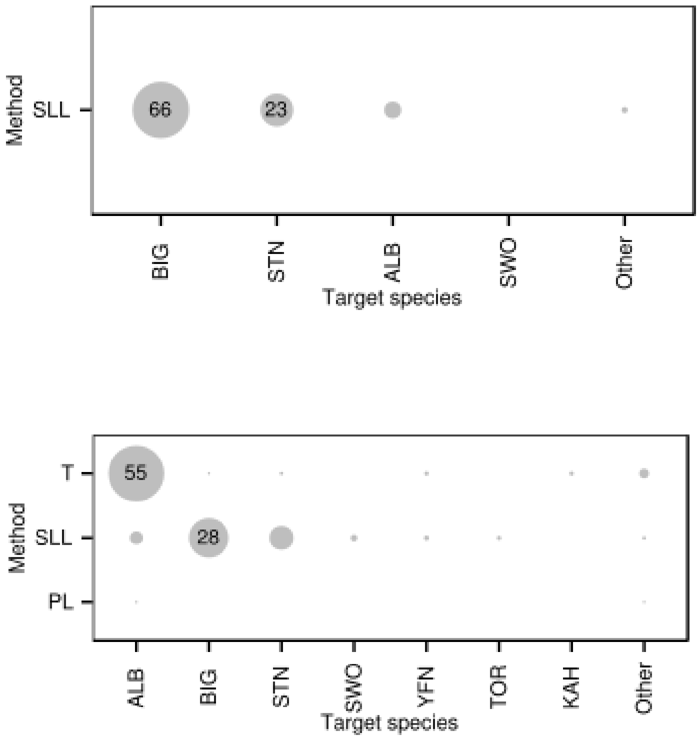


Figure 2: The proportion of effort in each of New Zealand's surface longline fisheries (top) and in all surface lining fisheries (bottom), (T – troll; SLL – surface longline; PL – pole & line). The area of each circle is proportional to the percentage of overall effort and the number in the circle is the percentage (Bentley et al 2013).

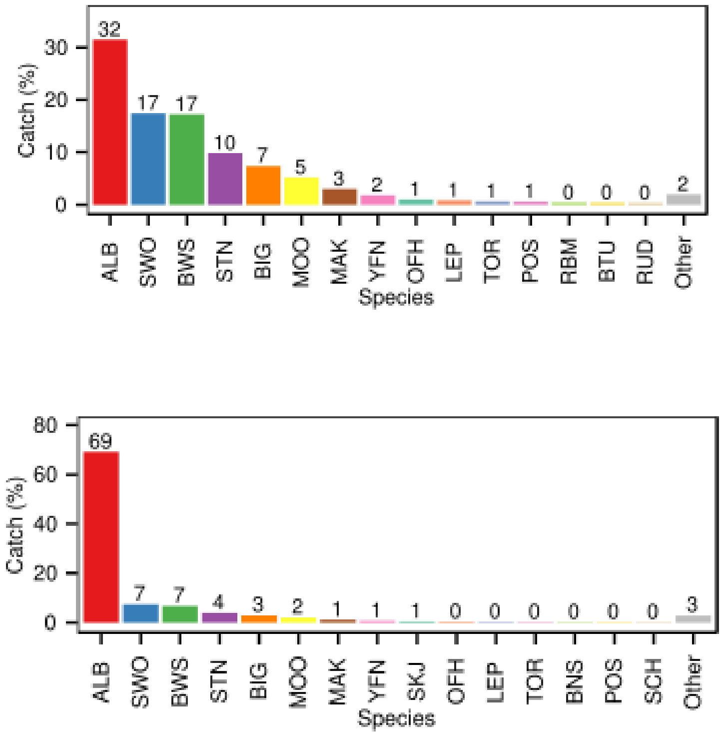


Figure 3: A summary of species composition by weight of the reported surface longline catch (top) and of the catch by all surface lining fisheries (bottom) (Bentley et al 2013).

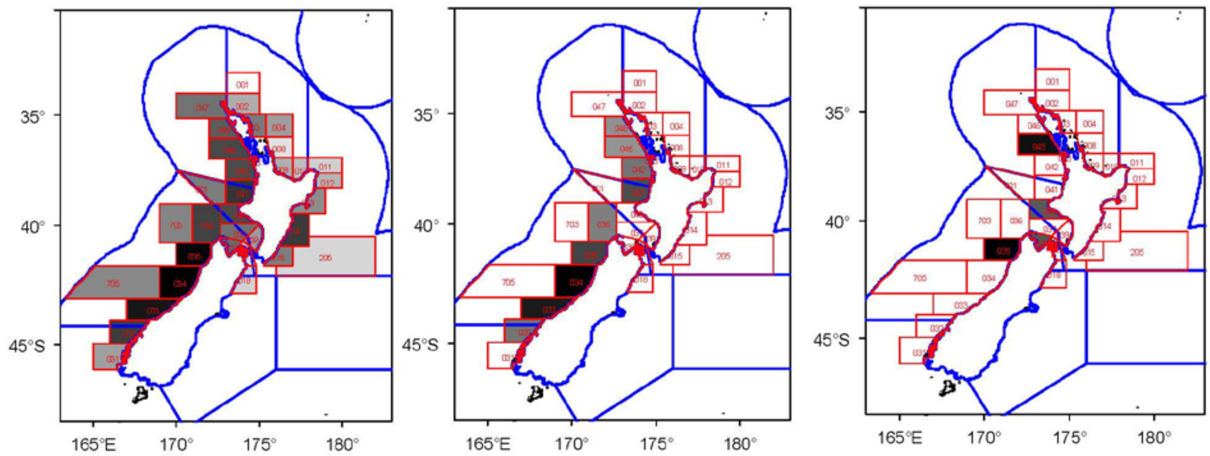


Figure 4: Plots showing the albacore catch by Statistical Area from CELR reporting forms (left); catch sampled in fish processing sheds (centre); and observed catch (right) for the 2011–12 fishing year.

Across all fleets in the longline fishery, 38.2% of albacore tuna were alive when brought to the side of the vessel (Table 2). The domestic fleets retained around 96–98% of their albacore tuna catch, while the foreign charter fleet retain almost all the albacore (98–100%). The Australian fleet that fished in New Zealand waters in 2006–07 also retained most of the albacore catch (92.4%) (Table 3).

Table 2: Percentage of albacore (including discards) that were alive or dead when arriving at the longline vessel and observed during 2006–07 to 2009–10, by fishing year, fleet and region. Small sample sizes (number observed < 20) were omitted Griggs & Baird (2013).

Year	Fleet	Area	% alive	% dead	Number
2006–07	Australia	North	21.5	78.5	79
	Charter	North	61.2	38.8	784
		South	77.3	22.7	587
	Domestic	North	28.1	71.9	1 880
	Total		**44.4**	**55.6**	**3 330**
2007–08	Charter	South	71.3	28.7	167
	Domestic	North	22.7	77.3	1 765
	Total		**26.9**	**73.1**	**1 932**
2008–09	Charter	North	84.6	15.4	410
		South	79.5	20.5	112
	Domestic	North	33.7	66.3	1 986
	Total		**44.0**	**56.0**	**2 511**
2009–10	Charter	South	82.1	17.9	78
	Domestic	North	28.8	71.2	1 766
		South	42.9	57.1	42
	Total		**31.3**	**68.7**	**1 886**
Total all strata			**38.2**	**61.8**	**9 659**

Table 3: Percentage albacore that were retained, or discarded or lost, when observed on a longline vessel during 2006–07 to 2009–10, by fishing year and fleet. Small sample sizes (number observed < 20) omitted Griggs & Baird (2013).

Year	Fleet	% retained	% discarded or lost	Number
2006–07	Australia	92.4	7.6	79
	Charter	97.7	2.3	1 448
	Domestic	96.1	3.9	1 882
	Total	**96.7**	**3.3**	**3 409**
2007–08	Charter	98.8	1.2	170
	Domestic	95.9	4.1	1 769
	Total	**96.1**	**3.9**	**1 939**
2008–09	Charter	99.7	0.3	605
	Domestic	97.8	2.2	1 993
	Total	**98.2**	**1.8**	**2 598**
2009–10	Charter	100.0	0.0	89
	Domestic	97.2	2.8	1 814
	Total	**97.3**	**2.7**	**1 903**
Total all strata		**97.1**	**2.9**	**9 849**

1.2 Recreational fisheries

Recreational fishers catch albacore by trolling. There is some uncertainty with all recreational harvest estimates for albacore as presented below. Bradford (1996, 1998) provides estimates of the recreational catch of albacore. While the information provided is restricted to 1993 and 1996, information on where and when catches are made and by what fishing methods is provided. Bradford indicates that recreational albacore catches are made in summer (91%) and autumn (9%) months by a mixture of trolling (73%) and lining from boats (27%) in the parts of FMA 1, FMA 2 and FMA 9 surveyed. The recreational survey in 1996 provides greater area coverage and Bradford provides estimates of the albacore catch from FMA 1, FMA 2, FMA 3, FMA 5, FMA 8 and FMA 9 as given in Table 4. The historic survey results suggest annual recreational catches of albacore were around 245–260 t.

A key component of estimating recreational harvest from diary surveys is determining the proportion of the population that fish. The Recreational Technical Working Group concluded that the harvest estimates from the diary surveys should be used only with the following qualifications: a) they may be very inaccurate; and b) the 1996 and earlier surveys contain a methodological error.

The provisional results of the national survey of amateur harvest in 2011–12 (Large Scale Multi Species Survey) estimated about 22 000 albacore tuna were kept with an estimated weight of 92 t. This is a similar harvest weight to that for skipjack tuna in the same survey.

Table 4: Estimates of recreational albacore catch by number and weight (t).

Year	Area	Catch (number)	Catch (t)
1993	MFish. North region	48 000	245
1996	FMA 1	16 000	82
	FMA 2	20 000	102
	FMA 3	< 500	< 2.5
	FMA 5	2 000	10
	FMA 8	5 000	26
	FMA 9	8 000	41
	1996 total	51 000 to 51 500	260 to 263

Source: Bradford (1996, 1998).

1.3 Customary non-commercial fisheries

It is uncertain whether albacore were caught by early Maori, although it is clear that they trolled lures (for kahawai) that are very similar to those still used by Tahitian fishermen for various small tunas. Given the number of other oceanic species known to Maori, and the early missionary reports of Maori regularly fishing several miles from shore, albacore were probably part of the catch of early Maori.

An estimate of the current customary catch is not available.

1.4 Illegal catch

There is no known illegal catch of albacore in the EEZ or adjacent high seas.

1.5 Other sources of mortality

Discarding of albacore has not been reported in the albacore troll fishery (based on limited observer coverage in the 1980s). Low discard rates (average 3.3%) have been observed in the longline fishery over the period 1991–92 to 1996–97. Of those albacore discarded, the main reason recorded by observers was shark damage. Similarly, the loss of albacore at the side of the vessel was low (0.6%). Mortality in the longline fishery associated with discarding and loss while landing is estimated at 1.8% of the albacore catch by longline.

2. BIOLOGY

The troll fishery catches juvenile albacore typically 5 to 8 kg in size with the mean fork length for 1996–97 to 2006–07 being 63.5 cm (Figure 5). Clear length modes associated with cohorts recruiting to the troll fishery are evident in catch length distributions. In 2006–07 three modes with median lengths of 51, 61, and 72 cm were visible, that correspond to the 1, 2, and 3 year old age classes.

The mean length of troll caught albacore in 2009–10 was 61.6 cm. The modal progressions in the available catch length frequency time series from 1996–97 to 2010–11 are of utility for estimating annual variations in albacore recruitment. Longline fleets typically catch much larger albacore over a broader size range (56–105 cm) with variation occurring as a function of latitude and season. The mean length of longline-caught albacore from 1987 to 2007 is 80.4 cm. The smallest longline caught albacore are those caught in May to June immediately north of the Sub-tropical Convergence Zone (STCZ). Fish further north at this time and fish caught in the EEZ in autumn and winter are larger. There is high inter-annual variation in the longline catch length composition although length modes corresponding to strong and weak cohorts are often evident between years.

Sampling of troll caught albacore has been carried out annually (except 2008–09) since the 1996–97 fishing year. The sampling programme aims to sample in the ports of Auckland, Greymouth and New Plymouth (which was included for the first time in 2003). Initially the programme aimed to sample 1000 fish per month in each port. In 2010 the sample targets were changed and the programme now aims to sample approximately 5000 fish per year and the sample targets (Table 5) are distributed throughout the season to reflect the fishing effort distribution. In addition, in each port at least 100 fish per month are sub-sampled for weight. Length weight relationships are presented in Table 6 and length frequency distributions are presented in Figure 5.

Table 5: Catch sample targets for length measurements in the New Zealand troll sampling programme.

Month	Target number of fish
December	400
January	1 600
February	1 600
March	1 000
April	400
Total	5 000

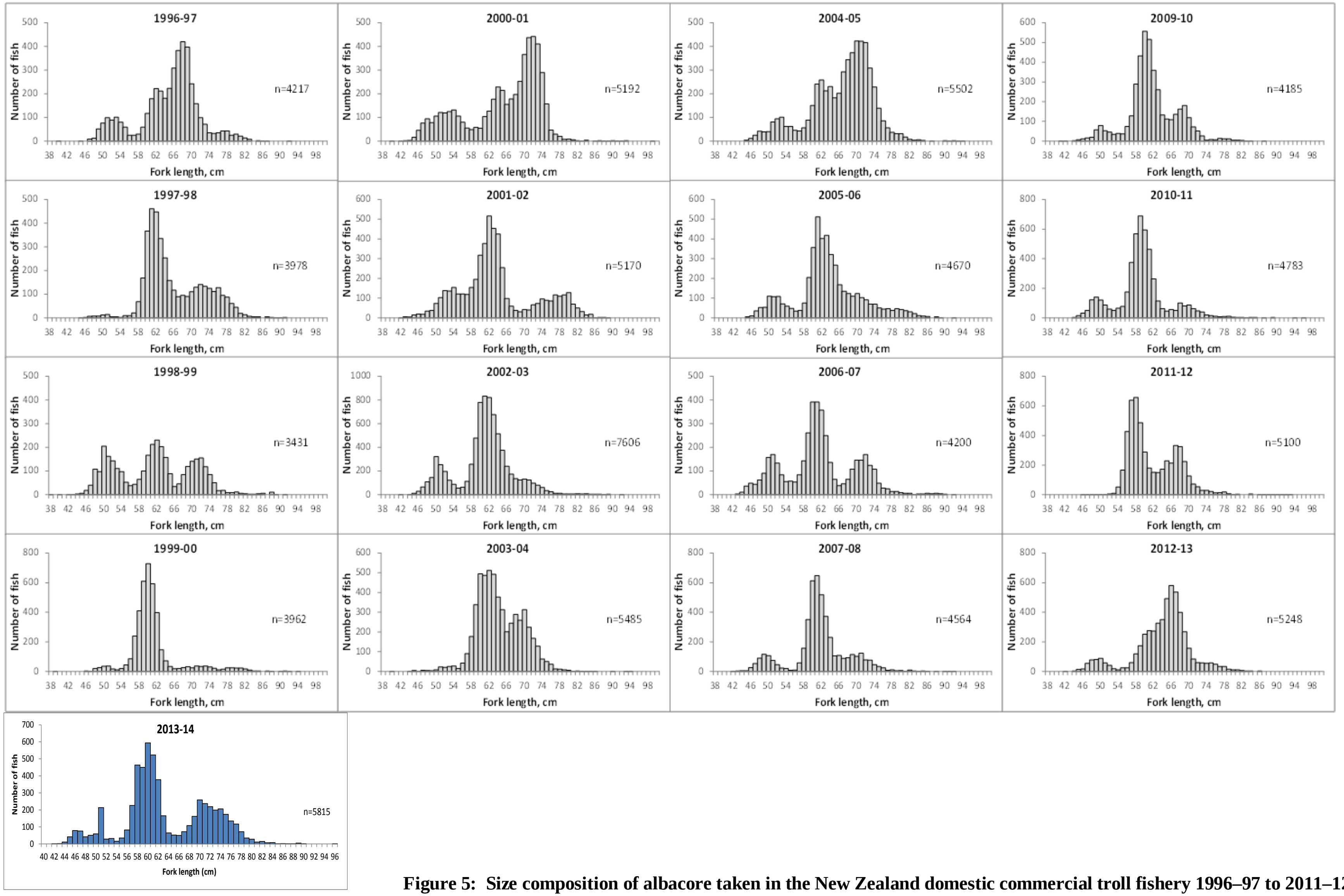


Figure 5: Size composition of albacore taken in the New Zealand domestic commercial troll fishery 1996–97 to 2011–12.

Histological gonadosomatic index analysis has shown that female albacore from New Caledonian and Tongan waters spawn from November–February.

Farley et al (2012) have recently completed a comprehensive analysis of South Pacific albacore biology. They found that otoliths were more reliable as ageing material then vertebrae. Their work using otoliths (validated by direct marking with oxytetracycline, and indirect methods) showed that the longevity of albacore was found to be at least 14 years, with significant variation in growth between sexes and across longitudes. They found that growth rates were similar between sexes up until age 4, after which the growth for males was on average greater than that for females, with males reaching an average maximum size more than 8 cm larger than females. Farley et al (2012) contend that the different growth rates between sexes may be responsible for the observed dominance of males among fish in the larger size classes (greater than 95 to 100 cm fork length). This study showed that growth rates were also consistently greater at more easterly longitudes than at westerly longitudes for both females and males. While they were not able to identify the determinants of the longitudinal variation in growth of albacore, they suggest that variation in oceanography, particularly the depth of the thermocline, may affect regional productivity and therefore play a role in modifying growth of South Pacific albacore.

Farley et al (2012) found that spawning was synchronised between 10 and 25°S during the austral summer. They confirmed that albacore spawn during the early hours of the morning and that they are capable of spawning daily, although spawning occurs on average every 1.3 days during peak spawning months. The number of eggs released per spawning event averaged 1.2 million oocytes. Although they were not able to sample females monthly in the region east of 175°E, they found no evidence of large variations in the reproduction or spawning dynamics of females across the southwest Pacific Ocean. Farley et al (2012) did, however, demonstrate that the proportion of females mature-at-length varied significantly with latitude in the Australian region, and that this variation was due to different geographic distributions of mature and immature fish during the year. A method was proposed to account for the latitudinal variation in maturity. Preliminary results of that analysis showed that the predicted age-at-50% maturity was 4.5 years, and the predicted age-at-100% maturity was age 7.

Sex ratios appear to vary with fishery from 1:1 (male:female) in the New Zealand troll and longline fishery and, 2:1 to 3:1 in the Tonga–New Caledonia longline fishery.

Estimates of growth parameters from Farley et al (2012) are presented in Table 7.

Table 6: The ln(length)/ln(weight) relationships of albacore [ln(greenweight) = b_0 + b_1 * ln(fork length)]. Weight is in kilograms and length in centimetres.

	n	b_0	SE b_0	b_1	SE b_1	R^2
Males	160	-10.56	0.18	2.94	0.04	0.97
Females	155	-10.10	0.26	2.83	0.06	0.93
Troll caught	320	-10.44	0.16	2.91	0.03	0.95
Longline caught	21 824	-10.29	0.03	2.90	0.01	0.91

Table 7: Parameter estimates (± standard error) from five candidate growth models fitted to length-at-age data for South Pacific albacore. Parameter estimates also given for the logistic model fitted separately to female and male length-at-age data. The small-sample bias-corrected form of Akaike's information criterion AICc are provided for each model fit, and Akaike differences AICcΔi, and Akaike weights *wi* are given for the fit of the five candidate models to all data. Note that the parameters *k* and *t* are defined differently in each model (see text for definitions), such that values are not comparable across models (Farley et al 2012).

Sex	Model	L_∞	k	t	p	δ	γ	v	AICc	ΔAICc	w_i
All	VBGM	104.52	0.40	-0.49					11831.67	23.89	0
		(0.44)	(0.01)	(0.05)							
	Gompertz	103.09	0.50	0.47					11811.54	3.77	0.08
		(0.37)	(0.01)	(0.03)							
	Logistic	102.09	0.61	1.12					11807.77	0.00	0.53
		(0.33)	(0.01)	(0.03)							
	Richards	102.30	0.58	0.98	1.32				11809.40	1.63	0.24
		(0.49)	(0.04)	(0.24)	(0.68)						
	Schnute-	101.52	0.05			-0.97	3.54	2.07	11810.25	2.48	0.15
	Richards	(0.60)	(0.08)			(0.08)	(2.65)	(0.76)			
Female	Logistic	96.97	0.69	0.99					5746.90		
		(0.37)	(0.02)	(0.03)							
Male	Logistic	105.34	0.59	1.25					5729.26		
		(0.44)	(0.02)	(0.04)							

3. STOCKS AND AREAS

Two albacore stocks (North and South Pacific) are recognized in the Pacific Ocean based on location and seasons of spawning, low longline catch rates in equatorial waters and tag recovery information. The South Pacific albacore stock is distributed from the coast of Australia and archipelagic waters of Papua New Guinea eastward to the coast of South America south of the equator to at least 49ºS. However, there is some suggestion of gene flow between the North and South Pacific stocks based on an analysis of genetic population structure.

Most catches occur in longline fisheries in the EEZs of other South Pacific states and territories and in high seas areas throughout the geographical range of the stock.

Troll and longline vessels catch albacore in all FMAs in New Zealand and there may be substantial potential for expansion to high seas areas.

4. ENVIRONMENTAL AND ECOSYSTEM CONSIDERATIONS

The figures and tables in this section were updated for the November 2014 Fishery Assessment Plenary after review of the text by the Aquatic Environment Working Group in 2014. This summary is from the perspective of the albacore longline fishery; a more detailed summary from an issue-by-issue perspective is available in the Aquatic Environment and Biodiversity Annual Review where the consequences are also discussed (http://www.mpi.govt.nz/Default.aspx?TabId=126&id=2122) (Ministry for Primary Industries 2013a).

4.1 Role in the ecosystem

Albacore (*Thunnus alalunga*) are apex predators, found in the open waters of all tropical and temperate oceans, feeding opportunistically on a mixture of fish, crustaceans, squid and juveniles also feed on a variety of zooplankton and micronecton species.

4.2 Incidental catch (seabirds, sea turtles and mammals)

The protected species, capture estimates presented here include all animals recovered onto the deck (alive, injured or dead) of fishing vessels but do not include any cryptic mortality (e.g., seabirds caught on a hook but not brought onboard the vessel.

4.3 Troll fishery

From 2006 to 2012 the troll catch averaged 93% albacore, the remaining 7% was made up mostly of teleosts (Table 8). The observer coverage of the troll fleet has been ongoing since 2006–07 and coverage has averaged 0.7% of the effort during that time; no protected species have been observed as bycatch in this fishery. The shed sampling programme has sampled on average 4.1% of the fishing effort during that time. Ray’s bream make up the bulk of the bycatch with minor catches of skipjack tuna, barracouta and kahawai (Table 8).

Table 8: Observed species composition of the albacore troll fishery. Number of fish recorded in the observer programme from 2006–07 to 2011–12, number in parentheses is the percentage of total catch.

		Number of fish caught						
Species	Scientific name	2006–07	2007–08	2008–09	2009–10	2010–11	2011–12	tal of 6 years
Albacore tuna	*Thunnus alalunga*	1684 (99.82)	1776 (98.89)	1755 (97.39)	5403 (88.01)	4913 (90.28)	2772 (98.68)	8303 (93.03)
Rays bream	*Brama brama*		18 (1.00)	12 (0.67)	537 (8.75)	35 (0.64)	7 (0.25)	609 (3.10)
Skipjack tuna	*Katsuwonus pelamis*	1 (0.06)	2 (0.11)	26 (1.44)	20 (0.33)	359 (6.60)	2 (0.07)	410 (2.08)
Barracouta	*Thyrsites atun*			1 (0.06)		126* (2.32)	13 (0.46)	140 (0.71)
Kahawai	*Arripis trutta*			6 (0.33)		5 (2.32)	14 (0.46)	25 (0.71)
Kingfish	*Seriola lalandi*			2 (0.11)	4 (0.07)	4 (0.07)		10 (0.13)
Dolphinfish	*Coryphaena hippurus*				1 (0.02)			1 (0.01)
Mako shark	*Isurus oxyrinchus*						1 (0.04)	1 (0.01)
Unidentified		2 (0.12)			174 (2.83)			176 (0.89)

*Includes one trip that landed 102 barracouta

Table 9: Number of albacore troll vessels, albacore landings, hooks set, and days fished and observed and the percentage observed, compared with those shed sampled.

	Fished				Observed				% Observed			
ALB–year	Days	Vessels	Landings	Hooks	Days	Vessels	Landings	Hooks	Days	Vessels	Landings	Hooks
2006–07	3 389	134	845	43 096	10	1	1	120	0.3	0.7	0.1	0.3
2007–08	4 479	153	1 296	54 092	8	1	1	120	0.2	0.7	0.1	0.2
2008–09	4 478	161	1 163	56 404	18	3	4	413	0.4	1.9	0.3	0.7
2009–10	3 196	120	856	39 511	49	6	10	637	1.5	5.0	1.2	1.6
2010–11	4 619	154	1 225	58 309	46	5	8	534	1.0	3.2	0.7	0.9
2011–12	4 817	155	1 370	60 592	24	1-2	9	317	0.5	1.3	0.7	0.5

	Shed sampled				% Shed sampled			
ALB–year	Days	Vessels	Landings	Hooks	Days	Vessels	Landings	Hooks
2006–07	125	14	21	1 817	3.7	10.4	2.5	4.2
2007–08	157	22	31	1 992	3.5	14.4	2.4	3.7
2008–09	0	0	0	0	0.0	0.0	0.0	0.0
2009–10	208	30	41	2 691	6.5	25.0	4.8	6.8
2010–11	237	35	48	3 097	5.1	22.7	3.9	5.3
2011–12	207	30	50	2 752	4.3	19.4	3.6	4.5

4.4 Longline

4.4.1 Seabird bycatch

Between 2002–03 and 2012–13, there were 73 observed captures of birds in albacore longline fisheries. Seabird capture rates since 2003 are presented in Figure 6, showing an indeterminate trend. Seabird capture locationss were more frequent off the east coast of the North Island and Kermadec Island regions (see Table 10 and Figure 7). Bayesian models of varying complexity dependent on data quality have been used to estimate captures across a range of methods (Richard & Abraham 2014). Observed and estimated seabird captures in albacore longline fisheries are provided in Table 11.

Through the 1990s the minimum seabird mitigation requirement for surface longline vessels was the use of a bird scaring device (tori line) but common practice was that vessels set surface longlines primarily at night. In 2007 a notice was implemented under s11 of the Fisheries Act 1996 to formalise the requirement that surface longline vessels only set during the hours of darkness and use a tori line when setting. This notice was amended in 2008 to add the option of line weighting and tori line use if setting during the day. In 2011 the notices were combined and repromulgated under a new regulation (Regulation 58A of the Fisheries (Commercial Fishing) Regulations 2001) which provides a more flexible regulatory environment under which to set seabird mitigation requirements.

Risk posed by commercial fishing to seabirds has been assessed via a level 2 method which supports much of the NPOA-Seabirds 2013 risk assessment framework (MPI 2013b). The method used in the level 2 risk assessment arose initially from an expert workshop hosted by the Ministry of Fisheries in 2008. The overall framework is described in Sharp et al. (2011) and has been variously applied and improved in multiple iterations (Waugh et al. 2009, Richard et al. 2011, Richard and Abraham 2013, Richard et al. 2013 and Richard & Abraham in press). The method applies an “exposure-effects” approach where exposure refers to the number of fatalities is calculated from the overlap of seabirds with fishing effort compared with observed captures to estimate the species vulnerability (capture rates per encounter) to each fishery group. This is then compared to the population’s productivity, based on population estimates and biological characteristics to yield estimates of population-level risk.

The 2014 iteration of the seabird risk assessment (Richard & Abraham in press) assessed the albacore target surface longline fishery contribution to the total risk posed by New Zealand commercial fishing to seabirds (see Table 12). This fishery contributes 0.002 of PBR_1 to the risk to Gibson’s albatross and 0.001 of PBR_1 to Southern Buller’s albatross; both species were assessed to be at very high from New Zealand commercial fishing (Richard & Abraham in press).

Table 10: Number of observed seabird captures in albacore longline fisheries, 2002–03 to 2012–13, by species and area. See glossary above for a description of the areas used for summarising the fishing effort and protected species captures. The risk ratio is an estimate of aggregate potential fatalities across trawl and longline fisheries relative to the Potential Biological Removals, PBR (from Richard and Abraham 2014) where full details of the risk assessment approach can be found). It is not an estimate of the risk posed by fishing for albacore using longline gear but rather the total risk for each seabird species. Other data, version 20140201 [Continued on next page].

Species	Risk ratio	East Coast North Island	Kermadec Islands	Northland and Hauraki	Total
Campbell black-browed albatross	High	14		3	17
Southern Buller’s albatross	Very high	8			8
Gibson’s albatross	Very high	7			7
Antipodean albatross	High	3			3
Salvin’s albatross	Very high	1			1
Total albatrosses	**N/A**	**33**	**0**	**3**	**36**

Table 10 [Continued]:

Grey-faced petrel	Negligible	2	11	4	17
Sooty shearwater	Negligible	8			8
Grey petrel	Low	3		2	5
White-chinned petrel	Medium	2			2
White-headed petrel	Negligible		2		2
Westland petrel	High	2			2
Black petrel	Very high			1	1
Total other seabirds	**N/A**	**17**	**13**	**7**	**37**

Table 11: Effort, observed and estimated seabird captures by fishing year for the albacore fishery within the EEZ. For each fishing year, the table gives the total number of hooks; the number of observed hooks; observer coverage (the percentage of hooks that were observed); the number of observed captures (both dead and alive); the capture rate (captures per thousand hooks); and the mean number of estimated total captures (with 95% confidence interval). Estimates are based on methods described in Thompson et al (2013) and are available via http://www.fish.govt.nz/en-nz/Environmental/Seabirds/. Estimates from 2002–03 to 2010–11 and preliminary estimates for 2012–13 are based on data version 20140131.

			Fishing effort	Observed captures		Estimated captures	
Fishing year	All hooks	Observed hooks	% observed	Number	Rate	Mean	95% c.i.
2002–2003	1 894 910	980 772	51.8	72	0.073	294	214–432
2003–2004	463 164	1 600	0.3	0	0	106	65–172
2004–2005	136 812	4 317	3.2	1	0.232	22	10–40
2005–2006	60 360	600	1	0	0	10	3–23
2006–2007	N/A	0	N/A	0	N/A	2	0–6
2007–2008	N/A	0	N/A	0	N/A	0	0–2
2008–2009	7 800	2 100	26.9	0	0	2	0–8
2009–2010	23 329	4 979	21.3	0	0	7	0–27
2010–2011	13 610	1 000	7.3	0	0	3	0–12
2011–2012	0	0	N/A	0	N/A	0	0–0
2012–2013†	N/A	0	N/A	0	N/A	4	0–17

†Provisional data, model estimates not finalised.

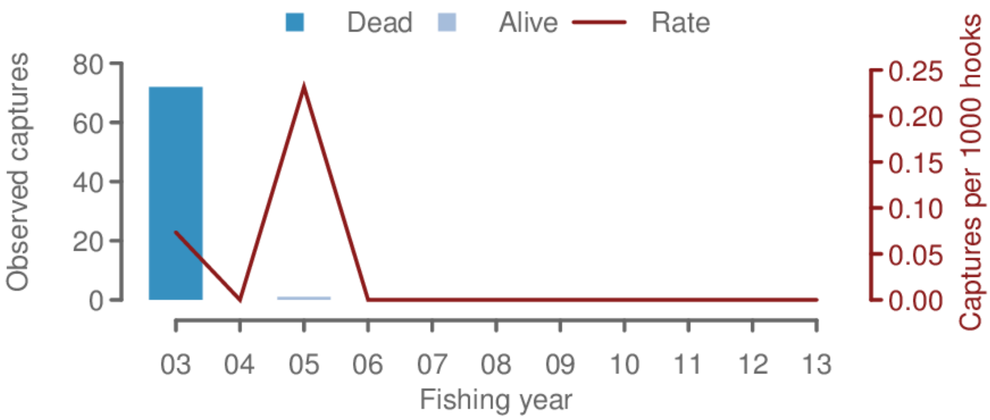


Figure 6: Observed captures of seabirds in albacore longline fisheries from 2002–03 to 2012–13 [Continued on next page].

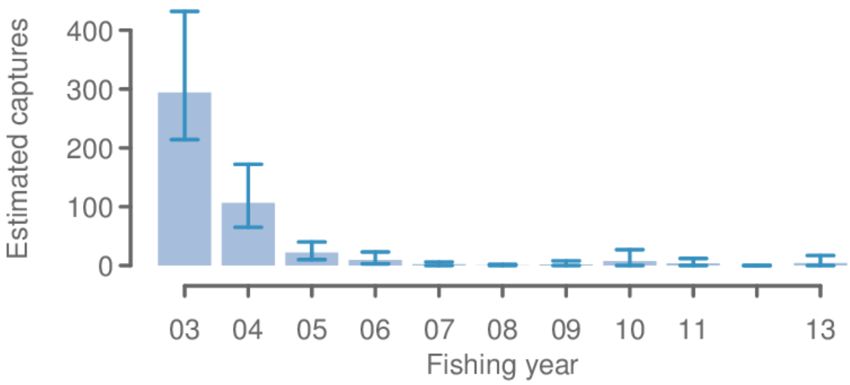


Figure 6 [Continued]: Estimated captures of seabirds in albacore longline fisheries from 2002–03 to 2012–13.

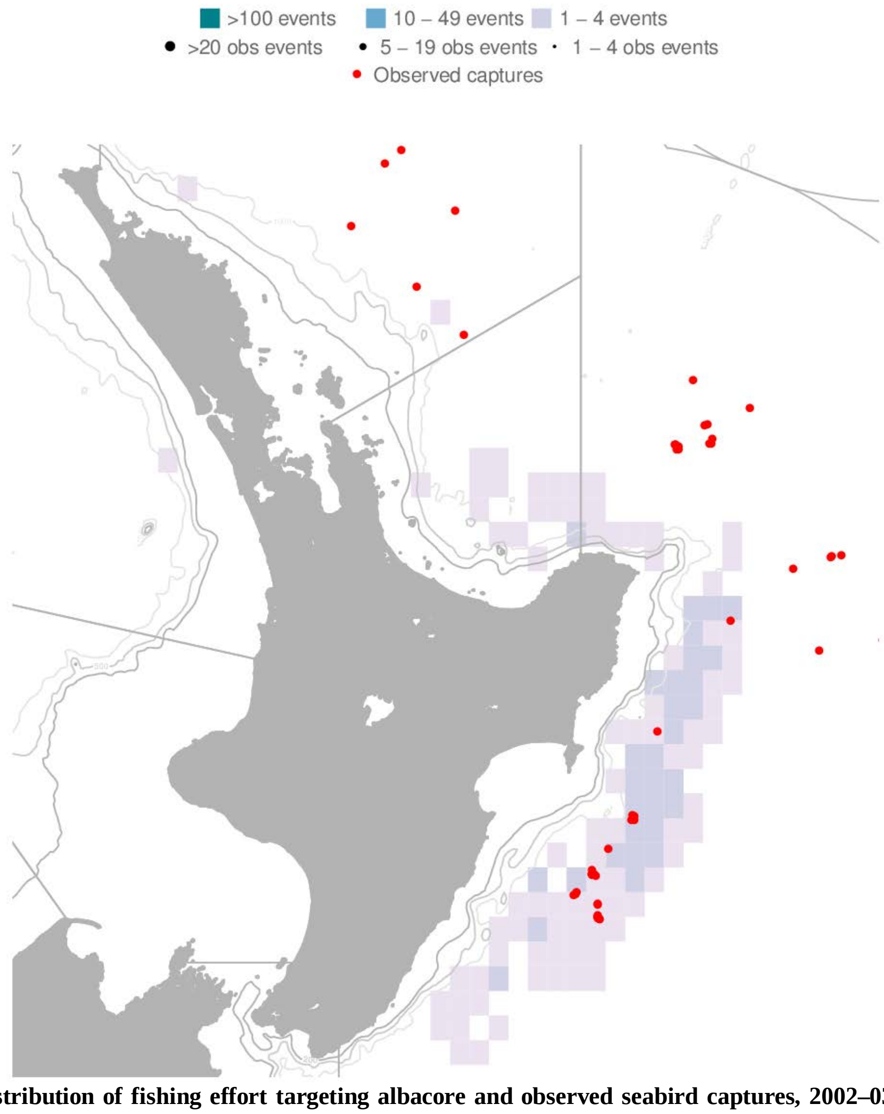


Figure 7: Distribution of fishing effort targeting albacore and observed seabird captures, 2002–03 to 2012–13. Fishing effort is mapped into 0.2-degree cells, with the colour of each cell being related to the amount of effort. Observed fishing events are indicated by black dots, and observed captures are indicated by red dots. Fishing is only shown if the effort could be assigned a latitude and longitude, and if there were three or more vessels fishing within a cell. In this case, 59.2% of the effort is shown. See glossary for areas used for summarising the fishing effort and protected species captures.

Table 12: Risk ratio of seabirds predicted by the level two risk assessment for the albacore target surface longline fishery and all fisheries included in the level two risk assessment, 2006–07 to 2012–13, showing seabird species with risk category of very or high, or a medium risk category and risk ratio of at least 1% of the total risk. The risk ratio is an estimate of aggregate potential fatalities across trawl and longline fisheries relative to the Potential Biological Removals, PBR_1 (from Richard and Abraham 2014 where full details of the risk assessment approach can be found). PBR_1 applies a recovery factor of 1.0. Typically a recovery factor of 0.1 to 0.5 is applied (based on the state of the population) to allow for recovery from low population sizes as quickly as possible. This should be considered when interpreting these results. The New Zealand threat classifications are shown (Robertson et al 2013 at http://www.doc.govt.nz/documents/science-and-technical/nztcs4entire.pdf)

	Risk ratio				
Species name	ALB target SLL	Total risk from NZ commercial fishing	% of total risk from NZ commercial fishing	Risk category	NZ Threat Classification
Black petrel	0.000	15.095	0.00	Very high	Threatened: Nationally Vulnerable
Salvin's albatross	0.000	3.543	0.00	Very high	Threatened: Nationally Critical
Southern Buller's albatross	0.001	2.823	0.03	Very high	At Risk: Naturally Uncommon
Flesh-footed shearwater	0.000	1.557	0.00	Very high	Threatened: Nationally Vulnerable
Gibson's albatross	0.002	1.245	0.14	Very high	Threatened: Nationally Critical
New Zealand white-capped albatross	0.000	1.096	0.01	Very high	At Risk: Declining
Chatham Island albatross	0.000	0.913	0.00	High	At Risk: Naturally Uncommon
Antipodean albatross	0.002	0.888	0.27	High	Threatened: Nationally Critical
Westland petrel	0.000	0.498	0.00	High	At Risk: Naturally Uncommon
Northern Buller's albatross	0.001	0.336	0.36	High	At Risk: Naturally Uncommon
Campbell black-browed albatross	0.000	0.304	0.00	High	At Risk: Naturally Uncommon
Stewart Island shag	0.000	0.301	0.00	High	Threatened: Nationally Vulnerable

4.4.2 Sea turtle bycatch

Between 2002–03 and 2012–13, there were no observed captures of turtles in albacore longline fisheries (Table 13 and Figure 8).

4.4.3 Marine Mammals

4.4.3.1 Cetaceans

Cetaceans are dispersed throughout New Zealand waters (Perrin et al 2008). The spatial and temporal overlap of commercial fishing grounds and cetacean foraging areas has resulted in cetacean captures in fishing gear (Abraham & Thompson 2009, 2011). Between 2002–03 and 2012–13, there was one observed capture of an unidentified cetacean in the albacore longline fisheries (Table 14, Table 15 and Figure 9) (Thompson et al 2013). This capture was recorded as being caught and released alive (Thompson & Abraham 2010). The cetacean capture took place in the Northland region (Figure 10).

Table 13: Effort and sea turtle captures by fishing year for the albacore fishery within the EEZ. For each fishing year, the table gives the total number of hooks; the number of observed hooks; observer coverage (the percentage of hooks that were observed); the number of observed captures (both dead and alive); and the capture rate (captures per thousand hooks). For more information on the methods used to prepare the data, see Thompson et al (2013).

	Fishing effort			Observed captures	
Fishing year	All hooks	Observed hooks	% observed	Number	Rate
2002–2003	1 894 910	980 772	51.8	0	0
2003–2004	463 164	1 600	0.3	0	0
2004–2005	136 812	4 317	3.2	0	0
2005–2006	60 360	600	1.0	0	0
2006–2007	N/A	0	N/A	0	N/A
2007–2008	N/A	0	N/A	0	N/A
2008–2009	7 800	2 100	26.9	0	0
2009–2010	23 329	4 979	21.3	0	0
2010–2011	13 610	1 000	7.3	0	0
2011–2012	0	0	N/A	0	N/A
2012–2013	N/A	0	N/A	0	N/A

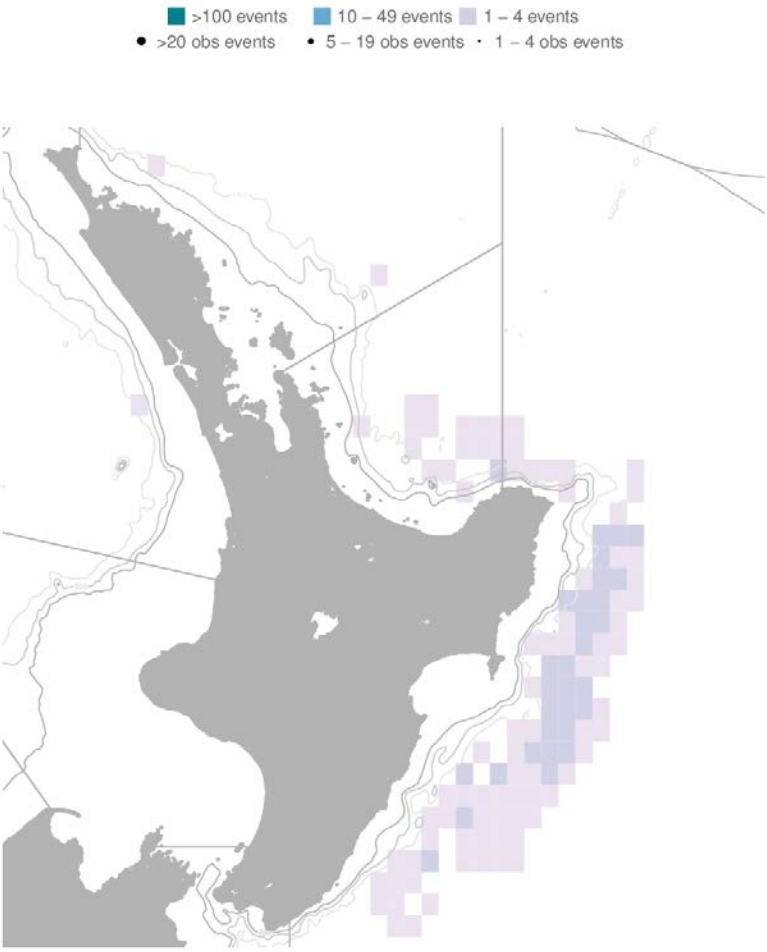


Figure 8: Distribution of fishing effort targeting albacore and observed sea turtle captures, 2002–03 to 2012–13. Fishing effort is mapped into 0.2-degree cells, with the colour of each cell being related to the amount of effort. Observed fishing events are indicated by black dots, and observed captures are indicated by red dots. Fishing is only shown if the effort could be assigned a latitude and longitude, and if there were three or more vessels fishing within a cell. In this case, 59.2% of the effort is shown. See glossary for areas used for summarising the fishing effort and protected species captures.

Table 14: Number of observed cetacean captures in albacore longline fisheries, 2002–03 to 2012–13, by species and area. Data from Thompson et al (2013), retrieved from http://data.dragonfly.co.nz/psc/. See glossary above for a description of the areas used for summarising the fishing effort and protected species captures.

	Northland and Hauraki	Total
Unidentified cetacean	1	1

Table 15: Effort and cetacean captures by fishing year for the albacore fishery within the EEZ. For each fishing year, the table gives the total number of hooks; the number of observed hooks; observer coverage (the percentage of hooks that were observed); the number of observed captures (both dead and alive); and the capture rate (captures per thousand hooks). For more information on the methods used to prepare the data, see Thompson et al (2013).

	Fishing effort			Observed captures	
Fishing year	All hooks	Observed hooks	% observed	Number	Rate
2002–2003	1 894 910	980 772	51.8	1	0.001
2003–2004	463 164	1 600	0.3	0	0
2004–2005	136 812	4 317	3.2	0	0
2005–2006	60 360	600	1.0	0	0
2006–2007	N/A	0	N/A	0	N/A
2007–2008	N/A	0	N/A	0	N/A
2008–2009	7 800	2 100	26.9	0	0
2009–2010	23 329	4 979	21.3	0	0
2010–2011	13 610	1 000	7.3	0	0
2011–2012	0	0	N/A	0	N/A
2012–2013	N/A	0	N/A	0	N/A

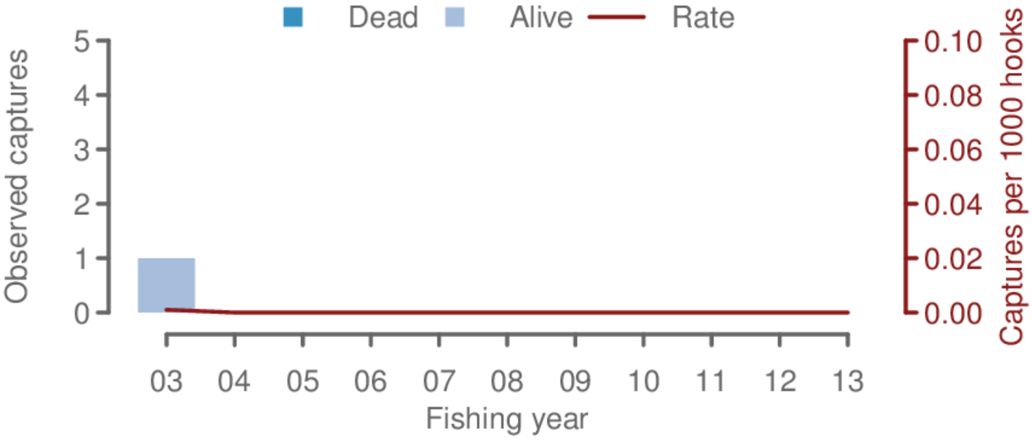


Figure 9: Observed captures of cetaceans in albacore longline fisheries from 2002–03 to 2012–13.

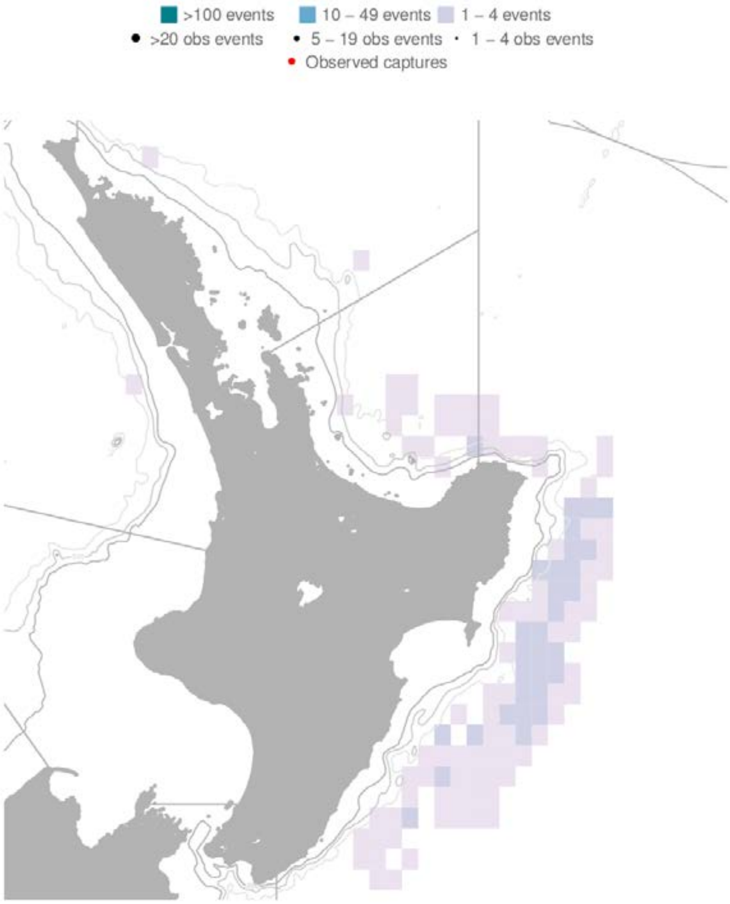


Figure 10: Distribution of fishing effort targeting albacore and observed cetacean captures, 2002–03 to 2012–13. Fishing effort is mapped into 0.2-degree cells, with the colour of each cell being related to the amount of effort. Observed fishing events are indicated by black dots, and observed captures are indicated by red dots. Fishing is only shown if the effort could be assigned a latitude and longitude, and if there were three or more vessels fishing within a cell. In this case, 59.2% of the effort is shown. See glossary for areas used for summarising the fishing effort and protected species captures.

4.4.3.2 New Zealand fur seal bycatch

Currently, New Zealand fur seals are dispersed throughout New Zealand waters, especially in waters south of about 40º S to Macquarie Island. The spatial and temporal overlap of commercial fishing grounds and New Zealand fur seal foraging areas has resulted in New Zealand fur seal captures in fishing gear (Mattlin 1987, Rowe 2009). Most fisheries with observed captures occur in waters over or close to the continental shelf, which slopes steeply to deeper waters relatively close to shore, and thus rookeries and haulouts, around much of the South Island and offshore islands. Captures on longlines occur when the fur seals attempt to feed on the bait and fish catch during hauling. Most New Zealand fur seals are released alive, typically with a hook and short snood or trace still attached.

New Zealand fur seal captures in surface longline fisheries have been generally observed in waters south and west of Fiordland, but also in the Bay of Plenty-East Cape area when the animals have attempted to take bait or fish from the line as it is hauled. Between 2002–03 and 2012–13, there were no observed captures of New Zealand fur seals in albacore longline fisheries (Thompson et al 2013) (Table 16 and Figure 11).

Table 16: Effort and captures of New Zealand fur seals by fishing year for the albacore longline fishery within the New Zealand EEZ. For each fishing year, the table gives the total number of hooks; the number of observed hooks; observer coverage (the percentage of hooks that were observed); the number of observed captures (both dead and alive); and the capture rate (captures per thousand hooks). Data from Thompson et al (2013), retrieved from http://data.dragonfly.co.nz/psc/. Estimates from 2002–03 to 2010–11 and preliminary estimates for 2012–13 are based on data version 20140131.

	Fishing effort			Observed captures	
Fishing year	All hooks	Observed hooks	% observed	Number	Rate
2002–2003	1 894 910	980 772	51.8	0	0
2003–2004	463 164	1 600	0.3	0	0
2004–2005	136 812	4 317	3.2	0	0
2005–2006	60 360	600	1.0	0	0
2006–2007	N/A	0	N/A	0	N/A
2007–2008	N/A	0	N/A	0	N/A
2008–2009	7 800	2 100	26.9	0	0
2009–2010	23 329	4 979	21.3	0	0
2010–2011	13 610	1 000	7.3	0	0
2011–2012	0	0	N/A	0	N/A
2012–2013†	N/A	0	N/A	0	N/A

†Provisional data, model estimates not finalised.

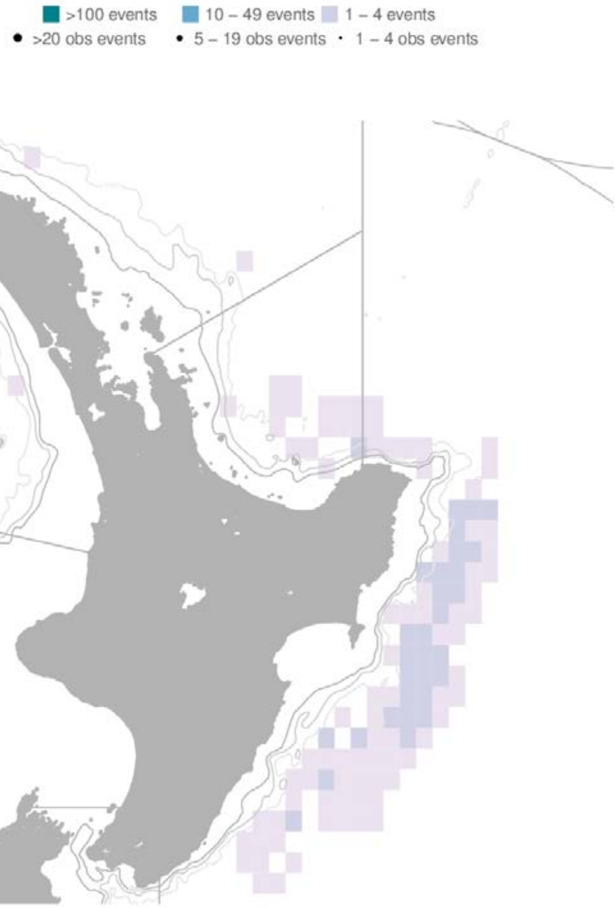


Figure 11: Distribution of fishing effort targeting albacore and observed fur seal captures, 2002–03 to 2012–13. Fishing effort is mapped into 0.2-degree cells, with the colour of each cell being related to the amount of effort. Observed fishing events are indicated by black dots, and observed captures are indicated by red dots. Fishing is only shown if the effort could be assigned a latitude and longitude, and if there were three or more vessels fishing within a cell. In this case, 59.2% of the effort is shown. See glossary for areas used for summarising the fishing effort and protected species captures.

4.5 Incidental fish bycatch

See above Section 4.3.

4.6 Benthic interactions

N/A

4.7 Key environmental and ecosystem information gaps

Cryptic mortality is unknown at present but developing a better understanding of this in future may be useful for reducing uncertainty of the seabird risk assessment and could be a useful input into risk assessments for other species groups.

The survival rates of released target and bycatch species is currently unknown.

Observer coverage in the New Zealand fleet is not spatially and temporally representative of the fishing effort.

5. STOCK ASSESSMENT

No assessment is possible for albacore within New Zealand fisheries waters as the proportion of the greater stock found within New Zealand fisheries waters is unknown and is likely to vary from year to year. With the establishment of WCPFC in 2004, stock assessments of the South Pacific Ocean (SPO) stock of albacore tuna are now undertaken by the Oceanic Fisheries Programme (OFP) of Secretariat of the Pacific Community (SPC) under contract to WCPFC.

The most recent South Pacific Ocean-wide assessment was undertaken in 2012 using MULTIFAN-CL (Hoyle et al 2012). A summary of that assessment can be found below:

This assessment uses the same underlying structural assumptions as the 2011 assessment, but used improved knowledge of albacore biology from the Farley et al (2012) study. The main conclusions of the assessment are Hoyle et al (2012):

a) Estimated stock status are based on the median of the grid and is similar to 2009 and 2011 estimates (Table 17; Figures 12–15).
b) “The fishing mortality reference point $F_{current}/F_{MSY}$ has a median estimate of 0.21 (90% CI 0.04–1.08), and on that basis we conclude that there is low risk that overfishing is occurring. The corresponding biomass-based reference points $B_{current}/B_{MSY}$ and $SB_{current}/SB_{MSY}$ are estimated to be above 1.0 (median 1.6 with range of 1.4–1.9, and median 2.6 with range of 1.5–5.2, respectively), and therefore the stock is not in an overfished state.
c) The median estimate of *MSY* from the structural sensitivity analysis (99 085 t (46 560 – 215 445 t) is comparable to the recent levels of (estimated) catch from the fishery ($C_{current}$ 78 664 t, C_{latest} 89 790 t).
d) There is no indication that current levels of catch are causing recruitment overfishing, particularly given the age selectivity of the fisheries.
e) Longline catch rates are declining, and catches over the last 10 years have been at historically high levels and are increasing. These trends may be significant for management.
f) Management quantities are very sensitive to the estimated growth curve. Given that biological research indicates spatial and sex-dependent variation in growth, which is not included in the model, these uncertainties should be understood when considering estimates of management parameters.”

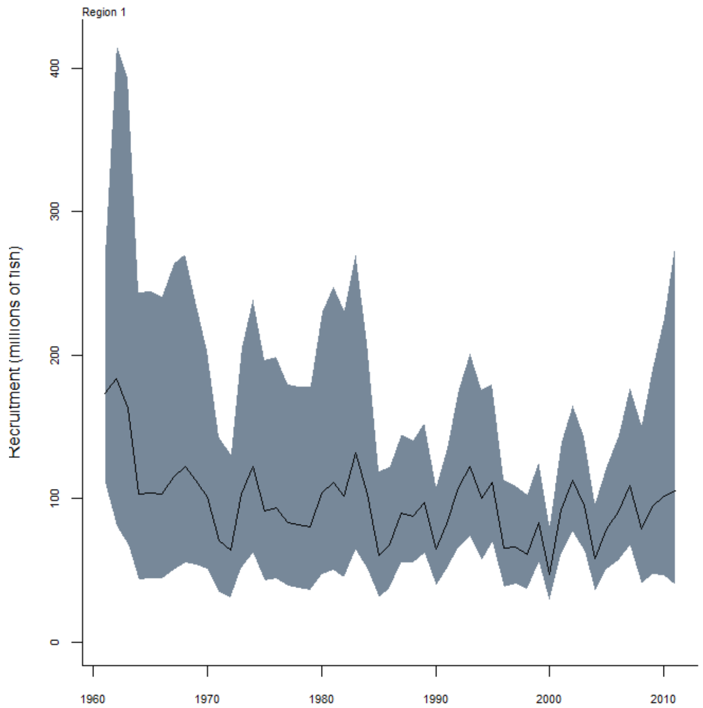


Figure 12: Annual recruitment (number of fish) estimates from the reference case model. The grey area represents parameter uncertainty estimated from the Hessian matrix Hoyle et al (2012).

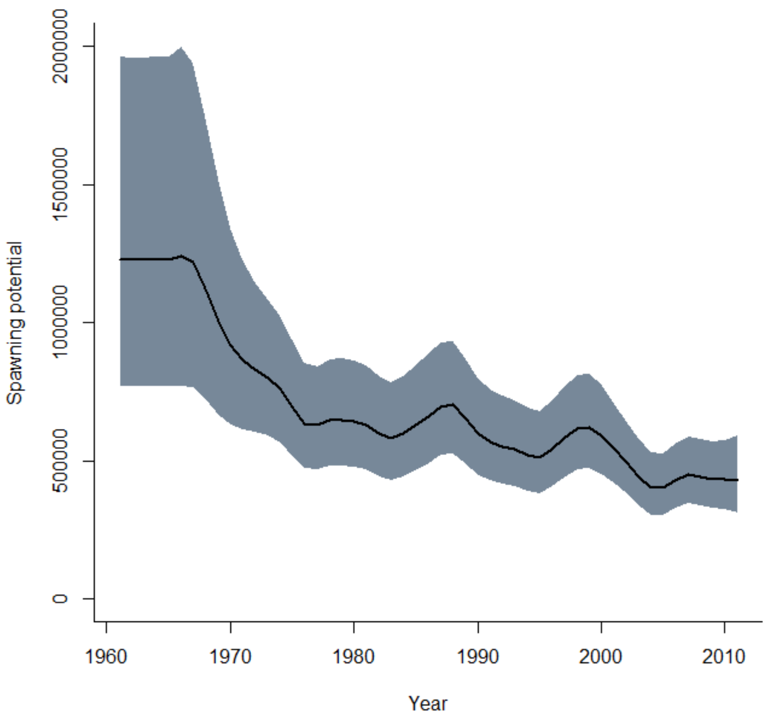


Figure 13: Annual estimates of spawning potential from the reference case model. The grey area represents parameter uncertainty estimated from the Hessian matrix Hoyle et al (2012).

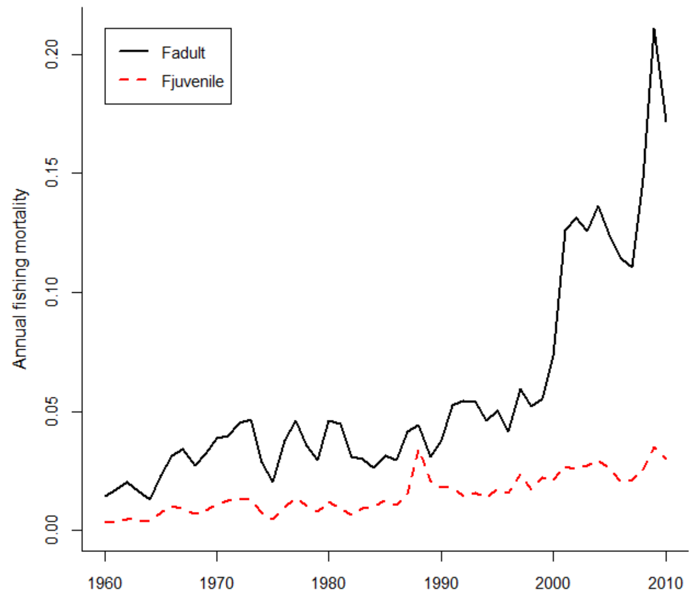


Figure 14: Annual estimates of fishing mortality for juvenile and adult South Pacific albacore from the reference case model Hoyle et al (2012).

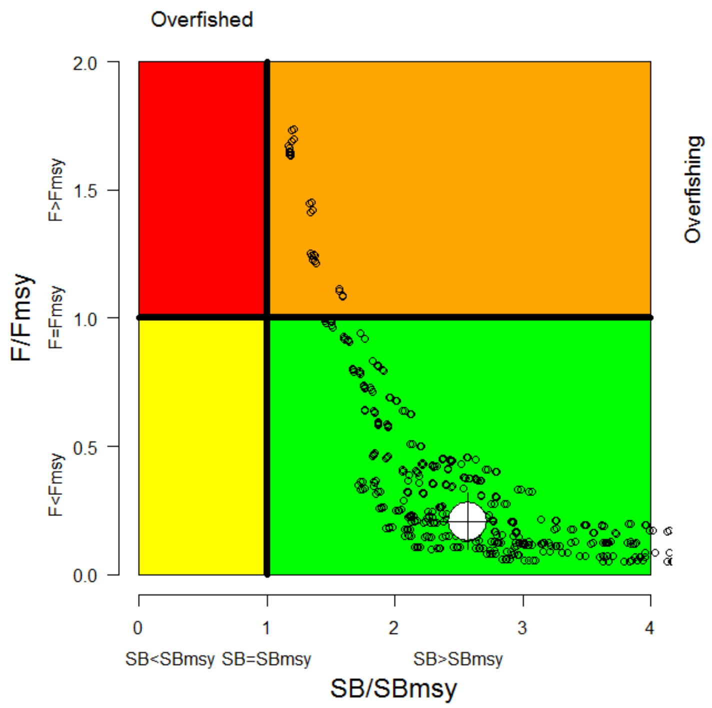


Figure 15: $F_{current}/F_{MSY}$ and $SB_{current}/SB_{MSY}$ for 540 model runs in the uncertainty grid (black hollow circles) and the median (large white circle). Note that some grid model runs extend as far as 7 for $SB_{current}/SB_{MSY}$ Hoyle et al (2012).

Table 17: Management parameters estimated from the 2012 base case (determined as the median from the structural uncertainty grid), the 2011 base case model, and the 2009 assessment, for comparison. Note that the definitions for current change through time Hoyle et al (2012).

Management quantity	2012 base case (grid median)	2011 base case	2009 base case	2009 median
$C_{current}$	78 664	54 520	66 869	65 801
C_{latest}	89 790	56 275		
MSY	99 085	85 130	97 610	81 580
$C_{current}/MSY$	0.79	0.64	0.69	0.80
C_{latest}/MSY	0.90	0.66		
F_{mult}	4.81	3.86		
$F_{current}/F_{MSY}$	0.21	0.26	0.25	0.29
SB_0	442 350	400 700	460 400	406 600
SB_{MSY}/SB_0	0.23	0.26	0.26	0.24
$SB_{current}/SB_0$	0.59	0.59	0.59	0.60
SB_{latest}/SB_0	0.56	0.47		
$SB_{current}/SB_{MSY}$	2.56	2.25	2.28	2.44
SB_{latest}/SB_{MSY}	2.38	1.82		
$SB_{curr}/SB_{curr_{F=0}}$	0.63	0.63	0.68	0.64
$SB_{latest}/SB_{latest_{F=0}}$	0.58	0.6		

Based on the assessment results the Scientific Committee concluded in 2012 that the South Pacific albacore stock is currently not overfished and overfishing is not occurring. Current biomass is sufficient to support current levels of catch. However, for several years the Scientific Committee has also noted that any increases in catch or effort are likely to lead to declines in catch rates in some regions, especially for longline catches of adult albacore, with associated impacts on vessel profitability.

The Scientific Committee noted the increasing catch and effort on South Pacific albacore south of the equator in both WCPFC and IATTC Convention areas, and is projected to result in a 16% reduction on average (range of 6% to 30% reduction) in vulnerable biomass by 2030 (as a proxy of CPUE) under 2012 conditions, and therefore impacting particularly on the vulnerable biomass available to SIDS domestic fleets and their profitability, The Scientific Committee recommends that longline fishing mortality and longline catch be reduced to avoid further decline in the vulnerable biomass and possibly exceeding the biomass limit reference point, and so that economically viable catch rates can be maintained.

5.1 Catch per unit effort indices (CPUE)

Relative abundance indices are an essential input to stock assessment models and are typically derived from a standardised CPUE time series. Studies have calculated CPUE indices for albacore caught in longline fisheries and for small juveniles caught in troll fisheries with fishing operational variables and environmental effects at appropriate resolution being examined as potentially significant factors in explaining the variance in CPUE models (Kendrick & Bentley 2010).

Catch and effort data collected using the detailed TLCER forms for the tuna longline fishery from 1993 to 2004 was groomed for input to the standardised CPUE analysis. A total of 51 004 data records were available with detailed effort information for individual fishing operations. These data have been linked to a range of environmental variables including remotely sensed observations for sea surface temperature (SST) and ocean colour (chlorophyll) at a spatial resolution corresponding closely with each individual fishing operation. These variables have been expressed in relation to oceanic fronts, climatology and oceanographic indices of mesoscale dynamics on both a seasonal and monthly temporal scale. Other potential explanatory variables include moon brightness (phase), day length, fraction of longline set during night hours, depth and depth variation.

Catch and effort information from the troll fishery, was collated from 1989–90 to 2007–08 fishing years and linked to sea surface temperature (SST) data at the coarser temporal (day) and spatial (Statistical Area) scale of CELR format data. The large fleet (over 700) of troll vessels was reduced to those that had completed at least five trips a year in at least four years. This still retained more than 220 vessels and the standardised CPUE analysis was repeated for batches of those vessels.

Longline

The categorical variables: year, quarter, nationality, experience, and target species were significant in explaining catch rate variability. Of the continuous variables sea surface temperature (SST) had the strongest effect, with highest catch rates in the range 18 to 19°C. SST features associated with ocean fronts were of lesser significance. In an albacore CPUE analysis, only a weak relationship was found between CPUE and the southern oscillation index (SOI), and this was largely attributed to recruitment fluctuations in response to SST variability associated with the index.

There is a dramatic decline in the longline albacore CPUE time series from 1998 to 2000 that corresponds closely to a large increase in swordfish catch from 1600 fish in 1997 to over 12 000 in 2001. This reciprocal pattern most likely reflects a shift in fishing practice in the longline fleet towards targeting for swordfish since the mid-1990s (Figure 16). This is likely to have altered the catchability of the longline fishery for albacore through a physical change in the configuration of the fishing gear. Despite this operational factor, the general decline since the mid-1990s is consistent with the trend observed in Taiwanese longline CPUE in the southern parts of the South Pacific region, and with the substantial decline in biomass since the late 1990s predicted by the regional assessment model. The decline following a peak in catch rates that occurred in 1995, has been attributed to a 7-year cycle in albacore catch rates that has been evident since 1978, and is a result of YCS variation in response to SOI cycles. This explanation describes a process that would potentially affect catch rates of albacore throughout the South Pacific region, and hence, the New Zealand longline fishery. It is therefore possible that the factors contributing to the dramatic decline observed in the New Zealand fishery include stock-wide changes in availability, as well as a change in fishing practices.

Troll

The year effects from models of two independent batches of core vessels resemble each other closely; each describing a series that oscillates in a 3–4 year cycle around unity with no overall upward or downward trend. The error bars around each point are small in comparison with the interannual variance and the effect on observed CPUE of standardising for variance in hours fished, Statistical Area, month and vessel participation is almost indiscernible. Local scale environmental variables including SST were not accepted into either analysis.

Within a troll season there is little contrast in catches among vessels or among the months and areas in which the fishery operates. The large interannual variance however agrees reasonably well with the El Niño/Southern Oscillation (ENSO) index (Figure 17). The availability of juvenile albacore to the troll fishery appears to correspond negatively with El Niño events and to respond positively and quite sensitively to any trend away from that state.

Larger scale environmental effects appear to match many of the extreme shifts in availability and the effect is more likely to happen outside of New Zealand waters and the New Zealand troll season. This conclusion is in contrast to earlier work that suggested oceanographic features on a smaller spatial scale than troll data are collected might be expected to relate strongly to catch rates.

CPUE of troll caught albacore within New Zealand waters is unlikely to index abundance of the stock but is rather an index of availability of these juvenile fish in New Zealand waters. The effect of SOI does not appear to be selective with respect to the three cohorts observed in the fishery but does negate any additional inference about their relative abundance.

5.2 Estimates of fishery parameters and abundance

There are no fishery-independent indices of abundance for the South Pacific stock. Relative abundance information is available from catch per unit effort data. Returns from tagging programmes provides information on rates of fishing mortality, however, the return rates are very low and lead to highly uncertain estimates of absolute abundance.

5.3 Biomass estimates

Estimates of absolute biomass are highly uncertain, however, relative abundance trends are thought to be more reliable. Spawning potential depletion levels ($SB_{curr}/SB_{curr F=0}$) of albacore were moderate at about 37%. However, depletion levels of the exploitable biomass is estimated between about 10% and 60%, depending on the fishery considered, having increased sharply in recent years particularly in the longline fisheries (Figure 18).

5.4 Yield estimates and projections

No estimates of *MCY* and *CAY* are available.

5.5 Other yield estimates and stock assessment results

No other yield estimates are available.

5.6 Other factors

Declines in CPUE have been observed in some Pacific Island fisheries. This is problematic for South Pacific states that rely on albacore for their longline fisheries. Given the recent expansion of the Pacific albacore fishery and recent declines in exploitable biomass available to longline fisheries, maintaining catch rates for Pacific Island states is important for the economic survival of their domestic longline operators.

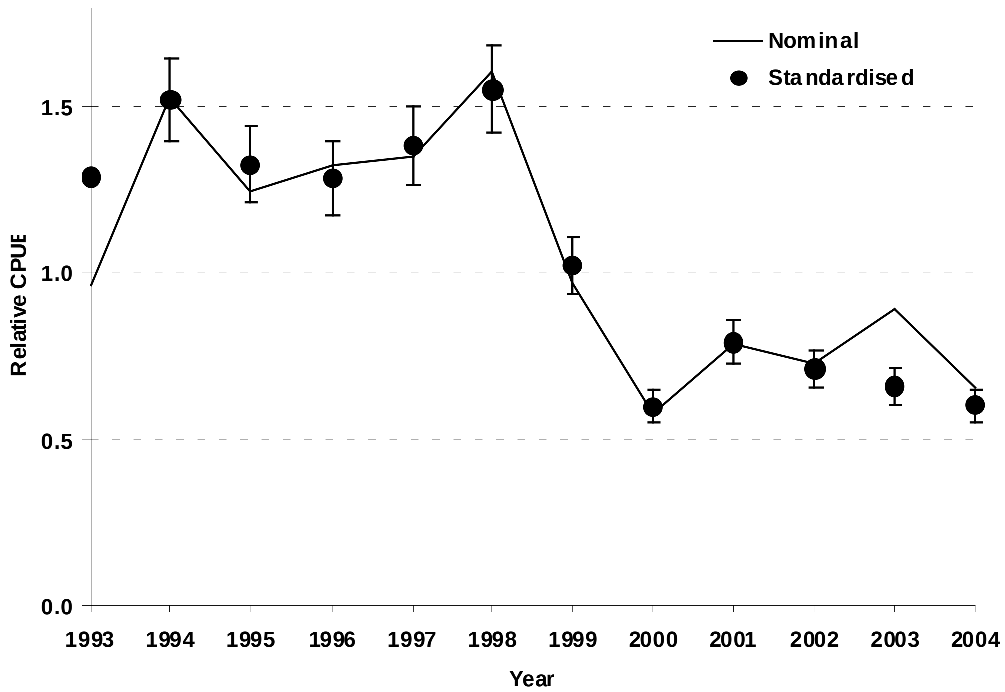


Figure 16: Nominal and standardised annual CPUE indices (normalised about the geometric mean for each time series) for the New Zealand domestic longline fishery, 1993–2004. Vertical bars indicate two standard errors (Unwin et al 2005).

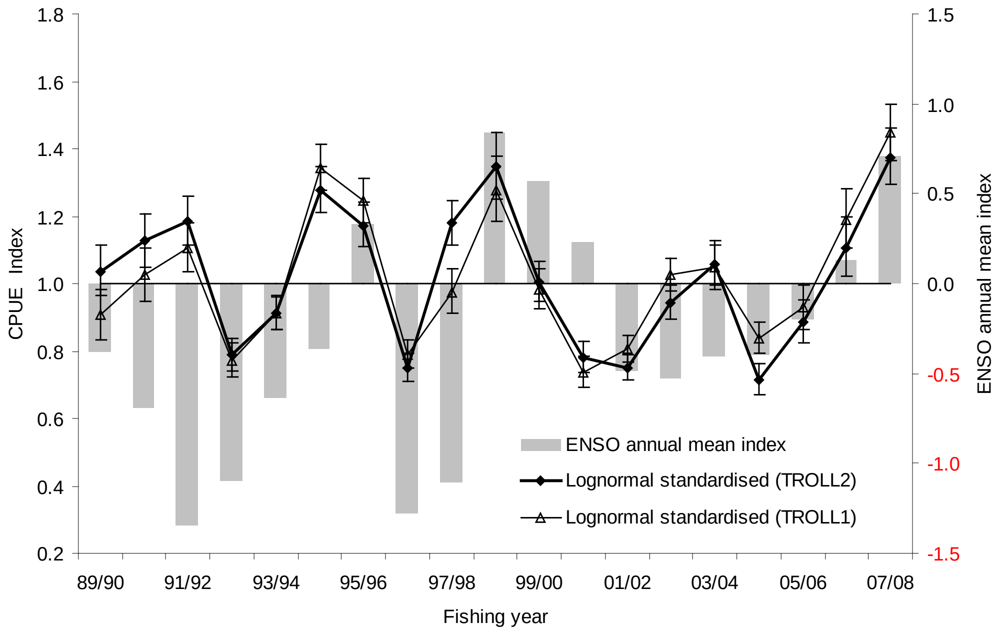


Figure 17: Comparison of annual indices of availability of troll-caught albacore in New Zealand waters (TROLL1 and TROLL2) with annual means of the Multivariate ENSO Index (MEI) an indicator of large climatic shifts affecting the South Pacific. Sign of ENSO index is reversed so that negative values indicate EL Nino events (Kendrick & Bentley 2010).

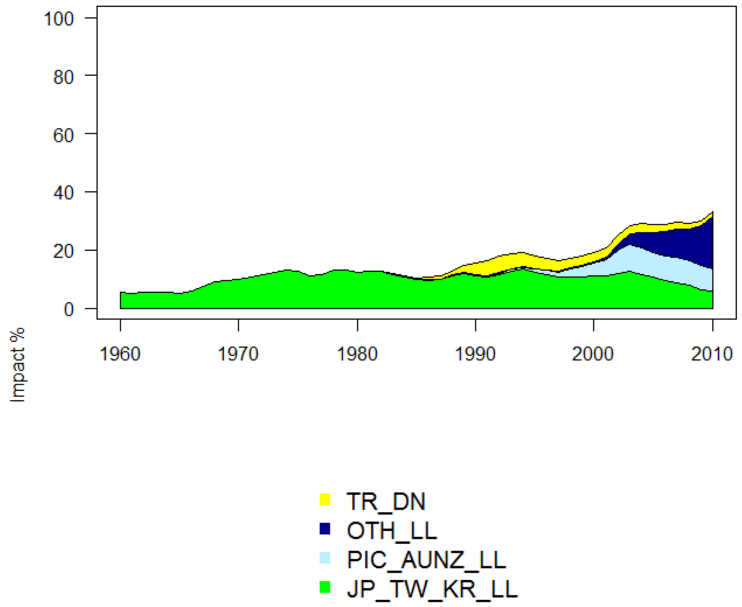


Figure 18: Estimates of reduction in spawning potential due to fishing (fishery impact = 1- $SB_t/SB_{tF=0}$) attributed to various fishery groups (TR_DN = Troll and driftnet fisheries; OTH_LL = 'Other' Longline fisheries; PIC_AUNZ_LL = Pacific Island and Australia and New Zealand longline fisheries; JP_TW_KR_LL = Japanese, Korean and Chinese Taipei distant water longline fisheries) (Hoyle et al 2012).

6. STATUS OF THE STOCK

Stock status is summarised from Hoyle (2011).

Stock structure assumptions

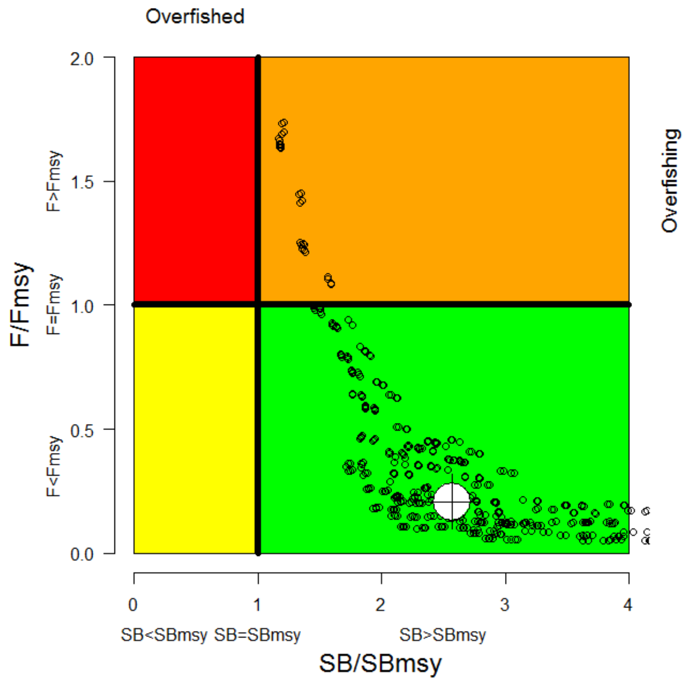
In the Western and Central Pacific Ocean, the South Pacific albacore stock is distributed from the coast of Australia and archipelagic waters of Papua New Guinea eastward to the coast of South

America south of the equator to at least 49ºS. However, there is some suggestion of gene flow between the North and South Pacific stocks based on an analysis of genetic population structure.

All biomass estimates in this table refer to spawning biomass (SB).

Stock Status	
Year of Most Recent Assessment	A full stock assessment was conducted in 2012.
Assessment Runs Presented	Base case model only
Reference Points	Target: $B > B_{MSY}$ and $F < F_{MSY}$ Soft Limit: Not established by WCPFC; but evaluated using HSS default of 20% SB_0 Hard Limit: Not established by WCPFC; but evaluated using HSS default of 10% SB_0 Overfishing threshold: F_{MSY}
Status in relation to Target	Likely (> 60%) that $B > B_{MSY}$ and Very Likely (> 90%) that $F < F_{MSY}$
Status in relation to Limits	Soft limit: Unlikely (< 40%) to be below Hard limit: Very Unlikely (< 10%) to be below
Status in relation to Overfishing	Overfishing is Very Unlikely (< 10%) to be occurring

Historical Stock Status Trajectory and Current Status



$F_{current}/F_{MSY}$ and $SB_{current}/SB_{MSY}$ for 540 model runs in the uncertainty grid (black hollow circles) and the median (large white circle). Note that some grid model runs extend as far as 7 for $SB_{current}/SB_{MSY}$ (Hoyle et al 2012).

Fishery and Stock Trends	
Recent Trend in Biomass or Proxy	The key conclusions of the models presented are that overfishing is not occurring and the stock is not in an overfished state. The assessment conclusions were broadly similar to those in 2011.
Recent Trend in Fishing Intensity or Proxy	The key conclusions of the assessment were broadly similar to those in 2011. Depletion levels (relative annual estimated biomass in the absence of fishing) of $F_{2007\text{-}2010}/F_{MSY}$ (0.21) and

	$SB_{2007-2010}/SB_{MSY}$ (2.56) do not indicate overfishing above F_{MSY}, nor that the fishery is in an overfished state below SB_{MSY}.
Other Abundance Indices	South Pacific albacore is the only WCPFC species that is assessed with standardised CPUE indices constructed with operational data. There was a rapid decline from the early 1960s until 1975 followed by a slower decline thereafter.
Trends in Other Relevant Indicator or Variables	-

Projections and Prognosis		
Stock Projections or Prognosis	There is no indication that current levels of catch are causing recruitment overfishing. However, current levels of fishing mortality may be affecting longline catch rates on adult albacore.	
Probability of Current Catch or TACC causing Biomass to remain below or to decline below Limits	Soft Limit: Unlikely (< 40%) to drop below ½ B_{MSY} Hard Limit: Very Unlikely (< 10%) to drop below ¼ B_{MSY}	
Probability of Current Catch or TACC causing Overfishing to continue or to commence	Very Unlikely (< 10%)	
Assessment Methodology and Evaluation		
Assessment Type	Level 1: Quantitative Stock assessment	
Assessment Method	The assessment uses the stock assessment model and computer software known as MULTIFAN-CL.	
Assessment Dates	Latest assessment: 2012	Next assessment: 2015
Overall assessment quality rank	1 – High Quality	
Main data inputs (rank)	The model is age structured (20 age-classes) and the catch, effort, size composition and tagging data used in the model are classified by 30 fisheries and quarterly time periods from July 1960 through June 2011.	1 – High Quality
Data not used (rank)	-	-
Changes to Model Structure and Assumptions	The structure of the assessment model was similar to the previous (2011) assessment, but there were some substantial revisions to key data sets which are noted above.	
Major Sources of Uncertainty	CPUE is used as an abundance index in the model. However, in the 1990s there was an increase in standardised CPUE in the west (regions 1 and 3) which was not evident in the east (regions 2 and 4). There was a decline in standardized CPUE for the Taiwan distant-water fleet since 2000 that also occurred in most domestic Pacific Island fisheries. It is not certain whether depressed CPUE since 2002 results from a decline in population abundance or a change in the availability of albacore in the South Pacific that affected the Taiwan fleet and domestic Pacific Island fleets (Bigelow & Hoyle 2009). There is also a conflict between the CPUE index and the longline length frequency data.	

Qualifying Comments
Although the latest assessment made some good improvements there is still a need to resolve the conflict between the CPUE and the longline length frequency data.
Fishery Interactions
Although no specific seabird/fishery interactions have been observed or reported for the troll fishery in New Zealand fishery waters, anecdotal reports and expert opinion consider that some albatross species are at risk of capture from this method. The troll fishery has a minor bycatch of Ray's bream. While longline albacore target sets are limited within New Zealand fishery waters interactions with protected species are known to occur in the longline fisheries of the South Pacific, particularly south of 25^{o}S. Seabird bycatch mitigation measures are required in the New Zealand and Australian EEZs and through the WCPFC Conservation and Management Measure CMM2007-04. Sea turtles are also incidentally captured in longline gear; the WCPFC is attempting to reduce sea turtle interactions through Conservation and Management Measure CMM2008-03. Shark bycatch is common in longline fisheries and largely unavoidable; this is being managed through New Zealand domestic legislation and to a limited extent through Conservation and Management Measure CMM2010-07.

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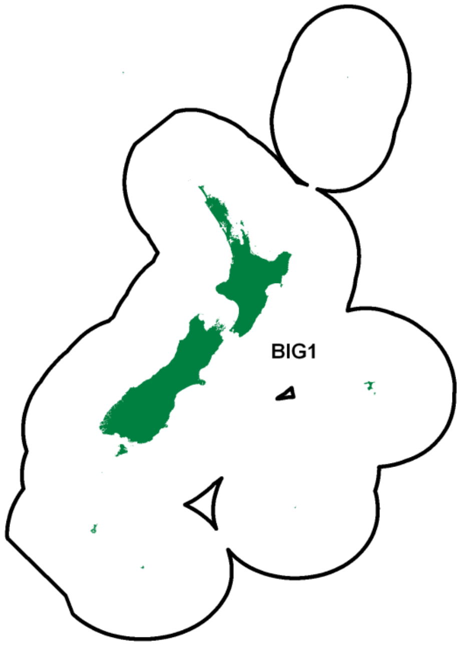
BIGEYE TUNA (BIG)

(Thunnus obesus)



1. FISHERY SUMMARY

Bigeye tuna were introduced into the QMS on 1 October 2004 under a single QMA, BIG 1, with allowances (t), TACC, and TAC in Table 1.

Table 1: Recreational and Customary non-commercial allowances, TACC and TAC (all in tonnes) by Fishstock.

Fishstock	Recreational Allowance	Customary non-commercial Allowance	Other mortality	TACC	TAC
BIG 1	8	4	14	714	740

Bigeye were added to the Third Schedule of the 1996 Fisheries Act with a TAC set under s14 because bigeye is a highly migratory species, and it is not possible to estimate MSY for the part of the stock that is found within New Zealand fisheries waters.

Management of the bigeye stock throughout the Western and Central Pacific Ocean (WCPO) is the responsibility of the Western and Central Pacific Fisheries Commission (WCPFC). Under this regional convention New Zealand is responsible for ensuring that the management measures applied within New Zealand fisheries waters are compatible with those of the Commission.

At its second annual meeting (2005) the WCPFC passed a Conservation and Management Measure (CMM) (this is a binding measure that all parties must abide by) relating to conservation and management of tunas. Key aspects of this resolution were presented in the 2006 Plenary document. That measure was reviewed by the Scientific Committee (SC) and further recommendations were made such that at its third annual meeting (2006) the WCPFC passed a new CMM relating to conservation and management of bigeye tuna (http://www.wcpfc.int). A further measure CMM2008-01 was agreed to in December 2008, the aim of which was to:

- "Ensure through the implementation of compatible measures for the high seas and EEZs that bigeye and yellowfin tuna stocks are maintained at levels capable of producing their maximum sustainable yield; as qualified by relevant environmental and economic factors including the special requirements of developing States in the Convention area as expressed by Article 5 of the Convention.

- Achieve, through the implementation of a package of measures, over a three-year period commencing in 2009, a minimum of 30% reduction in bigeye tuna fishing mortality from the annual average during the period 2001–2004 or 2004;
- Ensure that there is no increase in fishing mortality for yellowfin tuna beyond the annual average during the period 2001–2004 average or 2004; and
- Adopt a package of measures that shall be reviewed annually and adjusted as necessary by the Commission taking account of the scientific advice available at the time as well as the implementation of the measures. In addition, this review shall include any adjustments required by Commission decisions regarding management objectives and reference points."

This measure is large and detailed with numerous exemptions and provisions. Despite this effort reductions are being attempted through seasonal fish aggregating device (FAD) closures, and high seas area closures (in high seas pockets) for the purse seine fleets, longline effort reductions as well as other methods. At the 2009, 2010 and 2011 meetings the Scientific Committee recommended that this measure would need to be strengthened if it was to achieve its objectives.

1.1 Commercial fisheries

Commercial catches by distant water Asian longliners of bigeye tuna, in New Zealand fisheries waters, began in 1962 and continued under foreign license agreements until 1993. Bigeye were not a primary target species for these fleets and catches remained modest with the maximum catch in the 1980s reaching 680 t. Domestic tuna longline vessels began targeting bigeye tuna in 1990. There was an exponential increase in the number of hooks targeting bigeye which reached a high of approximately 6.6 million hooks in 2000–01 and then declined thereafter.

Catches from within New Zealand fisheries waters are very small (0.2% average for 2001–2009) compared to those from the greater stock in the WCPO (Tables 2 and 3). Figure 1 shows historical landings and TACC values for BIG 1 and BIG ET. Figure 1 shows historical longline fishing effort. In contrast to New Zealand, where bigeye are taken almost exclusively by longline, 40% of the WCPO catches of bigeye are taken by purse seine and other surface gears (e.g., ring nets).

1.2 Recreational fisheries

Recreational fishers make occasional catches of bigeye tuna while trolling for other tunas and billfish, but the recreational fishery does not regularly target this species. There is no information on the size of the catch.

1.3 Customary non-commercial fisheries

An estimate of the current customary catch is not available, but it is considered to be low.

1.4 Illegal catch

There is no known illegal catch of bigeye tuna in the EEZ.

1.5 Other sources of mortality

The estimated overall incidental mortality rate from observed longline effort is 0.23% of the catch. Discard rates are 0.34% on average (from observer data), of which approximately 70% are discarded dead (usually because of shark damage). Fish are also lost at the surface in the longline fishery, 0.09% on average (from observer data), of which 100% are thought to escape alive.

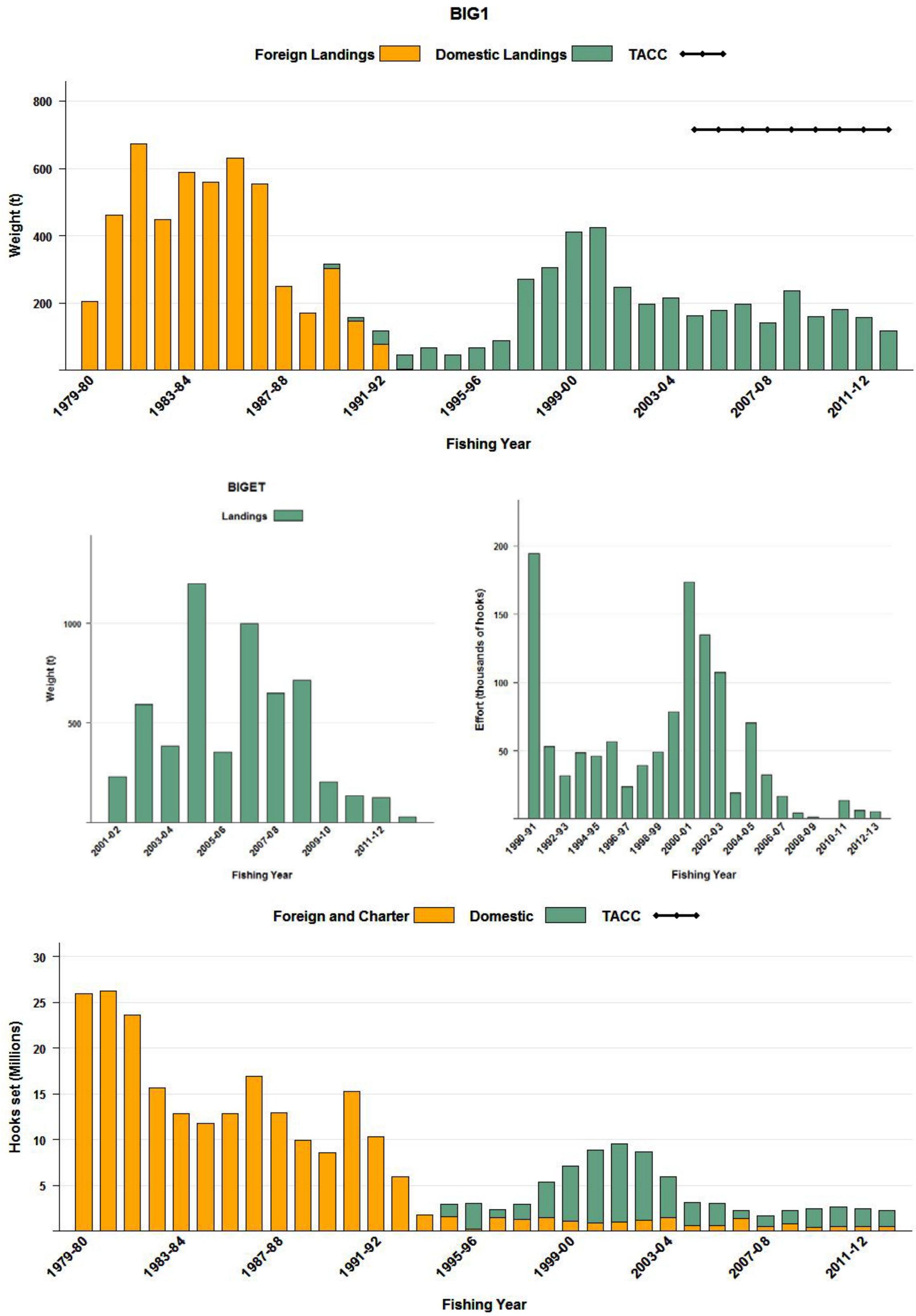


Figure 1: [Top and middle] Bigeye catch by foreign licensed and New Zealand vessels from 1979–80 to 2012–13 within New Zealand waters (BIG 1) and 2001–02 to 2012–13 for New Zealand vessels fishing on the high seas (BIG ET) (Anon 2012) and fishing effort (number of hooks set) for all high seas New Zealand flagged surface longline vessels from 1990–91 to 2012–13. [Bottom] Fishing effort (number of hooks set) for all domestic vessels (including effort by foreign vessels chartered by NZ fishing companies), from 1990–91 to 2012–13.

Table 2: Reported total New Zealand within EEZ landings* (t), landings from the Western and Central Pacific Ocean (t) of bigeye tuna by calendar year from 1991 to present, and NZ ET catch estimates from 2001 to present.

Year	NZ landings (t)	Total landings (t)	NZ ET SPC estimate	Year	NZ landings (t)	Total landings (t)	NZ ET SPC estimate	Year	NZ landings (t)	Total landings (t)	NZ ET SPC estimate
1991	44	100 608		1999	421	150 364		2007	213	134 258	651
1992	39	119 624		2000	422	133 449		2008	133	144 101	713
1993	74	103 557		2001	480	136 153	230	2009	254	149 545	204
1994	71	118 759		2002	200	161 996	593	2010	132	126 458	134
1995	60	107 406		2003	205	129 955	383	2011	174	146 254	125
1996	89	110 276		2004	185	178 556	1 198	2012	154	158 573	95
1997	142	152 862		2005	176	141 342	353	2013	110	145 883	81
1998	388	168 393		2006	178	151 646	997				

Source: Licensed Fish Receiver Returns, Solander Fisheries Ltd, Anon. (2006), Lawson (2008), WCPFC5-2008/IP11 (Rev. 2), Williams & Terawasi (2011) and WCPFC Yearbook 2012 Anon (2013).

*New Zealand purse seine vessel operating in tropical regions also catch small levels of bigeye when fishing around Fish Aggregating Devices (FAD). These catches are not included here at this time as the only estimates of catch are based on analysis of observer data across all fleets rather than specific data for NZ vessels. Bigeye catches are combined with yellowfin catches on most catch effort forms.

Table 3: Reported catches and landings (t) of bigeye tuna by fleet and Fishing Year. NZ: New Zealand domestic and charter fleet, ET: catches outside these areas from New Zealand flagged longline vessels, JPNFL: Japanese foreign licensed vessels, KORFL: foreign licensed vessels from the Republic of Korea, and LFRR: Estimated landings from Licensed Fish Receiver Returns.

	BIG 1 (all FMAs)					
Fishing Year	JPNFL	KORFL	NZ/MHR	Total	LFRR	NZ ET
1979–80	205.8			205.8		
1980–81	395.9	65.3		461.2		
1981–82	655.3	16.8		672.1		
1982–83	437.1	11.1		448.2		
1983–84	567.0	21.8		588.8		
1984–85	506.3	51.6		557.9		
1985–86	621.6	10.2		631.8		
1986–87	536.1	17.6		553.7		
1987–88	226.9	22.2		249.1		
1988–89	165.6	5.5		171.1	4.0	
1989–90	302.7		12.7	315.4	30.7	0.4
1990–91	145.6		12.6	158.2	36.0	0.0
1991–92	78.0		40.9	118.9	50.0	0.8
1992–93	3.4		43.8	47.2	48.8	2.2
1993–94			67.9	67.9	89.3	6.1
1994–95			47.2	47.2	49.8	0.5
1995–96			66.9	66.9	79.3	0.7
1996–97			89.8	89.8	104.9	0.2
1997–98			271.9	271.9	339.7	2.6
1998–99			306.5	306.5	391.2	1.4
1999–00			411.7	411.7	466.0	7.6
2000–01			425.4	425.4	578.1	13.6
2001–02			248.9	248.9	276.3	2.0
2002–03			196.1	196.1	195.1	0.6
2003–04			216.3	216.3	217.5	0.8
2004–05*			162.9	162.9	163.6	0.7
2005–06*			177.5	177.5	177.1	0.14
2006–07*			196.7	196.7	201.4	0.05
2007–08*			140.5	140.5	143.8	0
2008–09*			237.2	237.2	240.2	0
2009–10*			161.2	161.2	169.7	9.9
2010–11*			181.1	181.1	201.0	20.3
2011–12*			174.0	174.0	276.5	125.0
2012–13*			154.0	154.0	148.0	95.0

*MHR rather than LFRR data.

The majority of bigeye tuna (88%) are caught in the bigeye tuna target surface longline fishery (Figure 2). While bigeye are the target, albacore make up the bulk of the catch (34%) (Figure 3). Longline fishing effort is distributed along the east coast of the North Island and the south west coast of the South Island. The west coast South Island fishery predominantly targets southern bluefin tuna, whereas the east coast of the North Island targets a range of species including bigeye, swordfish, and southern bluefin tuna (Figure 4).

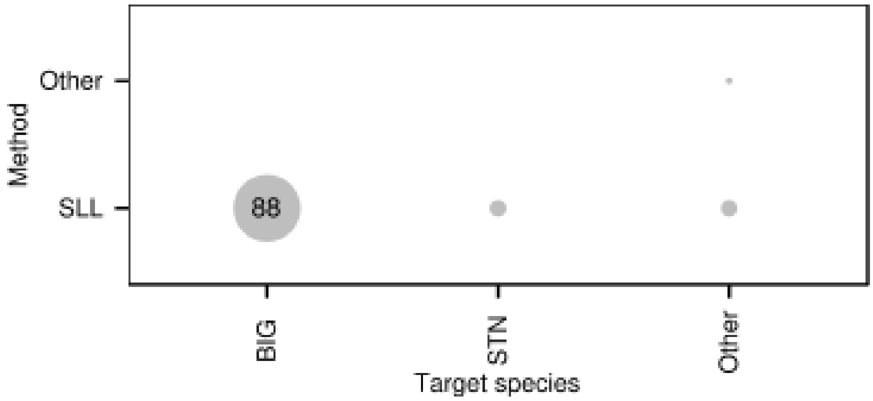


Figure 2: A summary of the proportion of landings of bigeye tuna taken by each target fishery and fishing method. The area of each circle is proportional to the percentage of landings taken using each combination of fishing method and target species. The number in the circle is the percentage. SLL = surface longline (Bentley et al 2013).

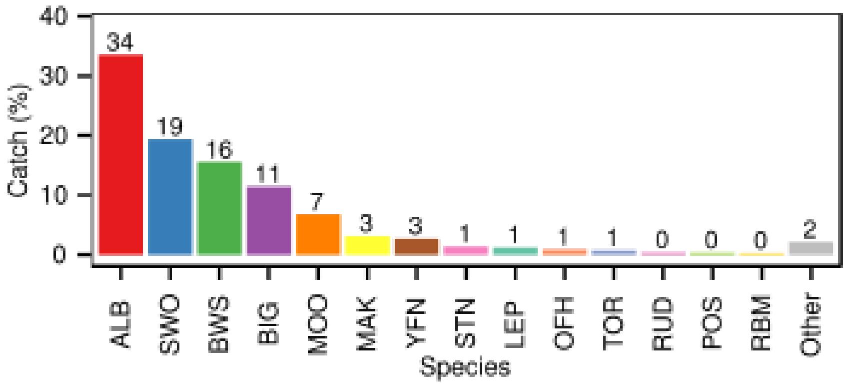


Figure 3: A summary of species composition of the reported bigeye target surface longline catch. The percentage by weight of each species is calculated for all surface longline trips targeting bigeye tuna (Bentley et al 2013).

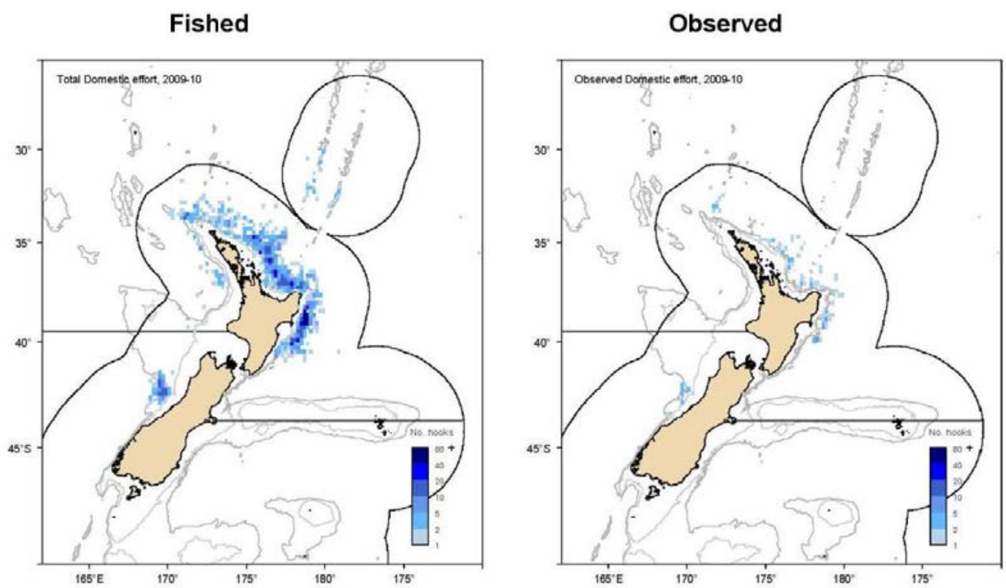


Figure 4: Distribution of fishing positions for domestic (top two panels) vessels, for the 2009–10 fishing year, displaying both fishing effort (left) and observed effort (right) [Continued on next page]

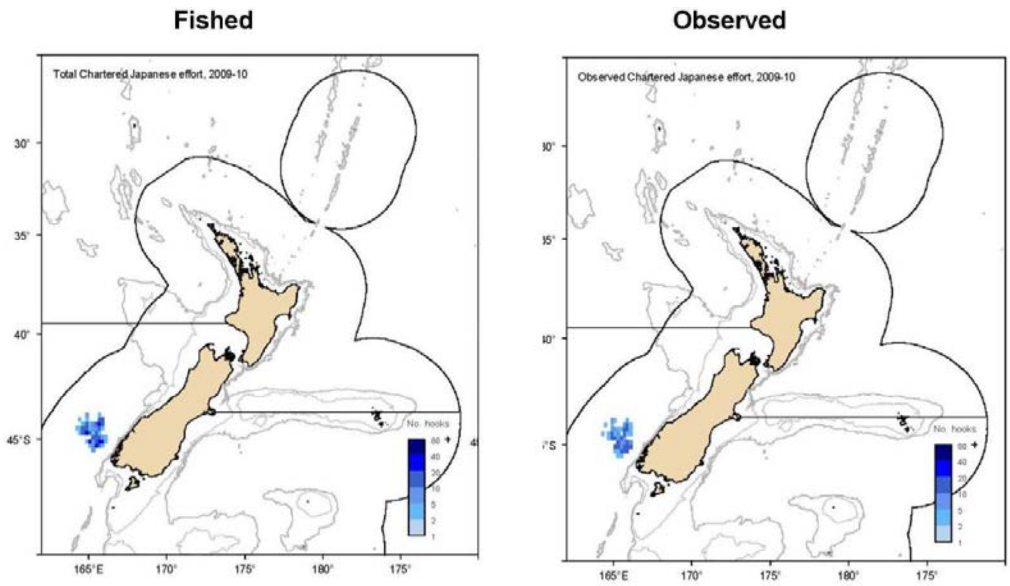


Figure 4 [Continued]: Distribution of fishing positions for charter (bottom two panels) vessels, for the 2009–10 fishing year, displaying both fishing effort (left) and observed effort (right).

2. BIOLOGY

Bigeye tuna are epi-pelagic opportunistic predators of fish, crustaceans and cephalopods generally found within the upper few hundred meters of the ocean. Tagged bigeye tuna have been shown to be capable of movements of over 4000 nautical miles over periods of one to several years. Juveniles and small adults school near the surface in tropical waters while adults tend to live in deeper water. Individuals found in New Zealand waters are mostly adults. Adult bigeye tuna are distributed broadly across the Pacific Ocean, in both the Northern and Southern Hemispheres and reach a maximum size of 210 kg and maximum length of 250 cm. The maximum reported age is 11 years old and tag recapture data indicate that significant numbers of bigeye reach at least 8 years old. Spawning takes place in the equatorial waters of the Western Pacific Ocean (WPO) in spring and early summer.

Natural mortality and growth rates are both estimated within the stock assessment. Natural mortality is assumed to vary with age with values about 0.5 for bigeye larger than 40 cm. A range of von Bertalanffy growth parameters has been estimated for bigeye in the Pacific Ocean depending on area (Table 4).

Table 4: Biological growth parameters for bigeye tuna, by country.

Country	L_∞ (cm)	K	t_0
Mexico	169.0	0.608	
French Polynesia	187.0	0.380	
Japan	195.0	0.106	-1.13
Hawaii	196.0	0.167	
Hawaii	222.0	0.114	
Hawaii	220.0	0.183	

3. STOCKS AND AREAS

Bigeye tuna are distributed throughout the tropical and sub-tropical waters of the Pacific Ocean. Analysis of mtDNA and DNA microsatellites in nearly 800 bigeye tuna failed to reveal significant evidence of widespread population subdivision in the Pacific Ocean (Grewe and Hampton 1998). While these results are not conclusive regarding the rate of mixing of bigeye tuna throughout the Pacific, they are broadly consistent with the results of SPC's and IATTC's tagging experiments on bigeye tuna. Before 2008, most bigeye tuna tagging in the Pacific occurred in the far eastern Pacific (east of about 120°W) and in the western Pacific (west of about 180°). While some of these tagged bigeye were recaptured at distances from release of up to 4,000 nautical miles over periods of one to several years, the large majority of tag returns were recaptured much closer to their release points (Schaefer and Fuller 2002; Hampton and Williams 2005). Since 2008, bigeye tuna tagging by the Pacific Tuna Tagging Programme has been focussed in the equatorial central Pacific, between 180° and 140°W. Returns of both conventional and electronic tags from this programme have been suggestive of more extensive longitudinal, particularly west to east, displacements (Schaefer et al. submitted). It is hypothesised that while bigeye tuna in the far eastern and western Pacific may have relatively little exchange, those in the central part of the Pacific between about 180° and 120°W may mix more rapidly over distances of 1,000 – 3,000 nautical miles. In any event, it is clear that there is extensive movement of bigeye across the nominal WCPO/EPO boundary of 150°W (Figure 2). While stock assessments of bigeye tuna are routinely undertaken for the WCPO and EPO separately, these new data suggest that examination of bigeye tuna exploitation and stock status on a Pacific-wide scale, using an appropriately spatially structured model, should be a high priority.

4. ENVIRONMENTAL AND ECOSYSTEM CONSIDERATIONS

This section was updated for the November 2014 Fishery Assessment Plenary after review by the Aquatic Environment Working Group. This summary is from the perspective of the bigeye tuna longline fishery; a more detailed summary from an issue-by-issue perspective is available in the Aquatic Environment and Biodiversity Annual Review where the consequences are also discussed (http://www.mpi.govt.nz/Default.aspx?TabId=126&id=2122) (Ministry for Primary Industries 2013a).

4.1 Role in the ecosystem

Bigeye tuna (*Thunnus obesus*) are epi-pelagic opportunistic predators of fish, crustaceans and cephalopods generally found within the upper few hundred meters of the ocean. Bigeye tuna are large pelagic predators, so they are likely to have a ‘top down’ effect on the fish, crustaceans and squid they feed on.

4.2 Incidental catch (seabirds, sea turtles and mammals)

The protected species, capture estimates presented here include all animals recovered onto the deck (alive, injured or dead) of fishing vessels but do not include any cryptic mortality (e.g., seabirds caught on a hook but not brought onboard the vessel).

4.2.1 Seabird bycatch

Between 2002–03 and 2012–13, there were 74 observed captures of birds in bigeye target longline fisheries (Table 5). Seabird capture rates since 2003 are presented in Figure 5. Capture rates increased from low levels in 2002-03 to high levels in 2007-08 and 2009-10 and declined since. Seabird captures were more frequent off the east coast of the North Island and Kermadec Island regions (see Table 10 and Figure 7). Bayesian models of varying complexity dependent on data quality have been used to estimate captures across a range of methods (Richard & Abraham 2014). Observed and estimated seabird captures in bigeye longline fisheries are provided in Table 11.

Through the 1990s the minimum seabird mitigation requirement for surface longline vessels was the use of a bird scaring device (tori line) but common practice was that vessels set surface longlines primarily at night. In 2007 a notice was implemented under s11 of the Fisheries Act 1996 to formalise the requirement that surface longline vessels only set during the hours of darkness and use a tori line when setting. This notice was amended in 2008 to add the option of line weighting and tori line use if setting during the day. In 2011 the notices were combined and repromulgated under a new regulation (Regulation 58A of the Fisheries (Commercial Fishing) Regulations 2001) which provides a more flexible regulatory environment under which to set seabird mitigation requirements.

Risk posed by commercial fishing to seabirds has been assessed via a level 2 method which supports much of the NPOA-Seabirds 2013 risk assessment framework (MPI 2013b). The method used in the level 2 risk assessment arose initially from an expert workshop hosted by the Ministry of Fisheries in 2008. The overall framework is described in Sharp et al. (2011) and has been variously applied and improved in multiple iterations (Waugh et al. 2009, Richard et al. 2011, Richard and Abraham 2013, Richard et al. 2013 and Richard & Abraham in press). The method applies an “exposure-effects” approach where exposure refers to the number of fatalities is calculated from the overlap of seabirds with fishing effort compared with observed captures to estimate the species vulnerability (capture rates per encounter) to each fishery group. This is then compared to the population’s productivity, based on population estimates and biological characteristics to yield estimates of population-level risk.

The 2014 iteration of the seabird risk assessment (Richard & Abraham in press) assessed the bigeye target surface longline fishery contribution to the total risk posed by New Zealand commercial fishing to seabirds (see Table 12). This fishery contributes 0.886 of PBR_1 to the risk to black petrel and 0.299 of PBR_1 to Gibson’s albatross; both species were assessed to be at very high from New Zealand commercial fishing. This fishery also contributes to the risk of high risk species; 0.207 of PBR_1 to Antipodean albatross and 0.190 of PBR_1 to North Buller’s albatross (Richard & Abraham in press).

Table 5: Number of observed seabird captures in bigeye tuna longline fisheries, 2002–03 to 2012–13, by species and area. See glossary above for a description of the areas used for summarising the fishing effort and protected species captures. The risk ratio is an estimate of aggregate potential fatalities across trawl and longline fisheries relative to the Potential Biological Removals, PBR (from Richard and Abraham (2014) where full details of the risk assessment approach can be found). It is not an estimate of the risk posed by fishing for bigeye tuna using longline gear but rather the total risk for each seabird species. Other data, version 20140201.

Species	Risk ratio	Northland and Hauraki	East Coast North Island	West Coast North Island	Bay of Plenty	Kermadec Islands	Total
Southern Buller’s albatross	Very high	5	4				9
Antipodean albatross	High	6		1	1		8
Gibson’s albatross	Very high	7		1			8
Salvin’s albatross	Very high	1	2		1		4
Wandering albatross	N/A	2	1				3
Campbell black-browed albatross	High	3					3
Antipodean and Gibson’s albatross	N/A	2					2
Albatrosses	N/A			1			1
Black-browed albatrosses	N/A			1			1
Northern royal albatross	Medium				1		1
Southern royal albatross	Low	1					1
Wandering albatrosses	N/A	1					1
New Zealand white-capped albatross	Very high	1					1
Total albatrosses	N/A	29	7	4	3	0	43
Flesh-footed shearwater	Very high		9	2			11
Black petrel	Very high	8			1	1	10
White-chinned petrel	Medium	2		3	3		8
Grey-faced petrel	Negligible				1		1
Gadfly petrels	N/A	1					1
Total other seabirds	N/A	11	9	5	5	1	31

Table 6: Effort, observed and estimated seabird captures by fishing year for the bigeye tuna fishery within the EEZ. For each fishing year, the table gives the total number of hooks; the number of observed hooks; observer coverage (the percentage of hooks that were observed); the number of observed captures (both dead and alive); the capture rate (captures per thousand hooks); and the mean number of estimated total captures (with 95% confidence interval). Estimates are based on methods described in Thompson et al (2013) and are available via http://www.fish.govt.nz/en-nz/Environmental/Seabirds/. Estimates from 2002–03 to 2010–11 and preliminary estimates for 2012–13 are based on data version 20140131.

	Fishing effort			Observed captures		Estimated captures	
Fishing year	All hooks	Observed hooks	% observed	Number	Rate	Mean	95% c.i.
2002–2003	5 188 107	80 640	1.6	0	0	1 250	918–1 759
2003–2004	3 507 307	120 740	3.4	1	0.008	867	628–1 230
2004–2005	1 648 181	33 116	2	2	0.06	333	237–468
2005–2006	1 867 706	45 100	2.4	6	0.133	468	345–657
2006–2007	1 532 071	84 150	5.5	5	0.059	424	305–600
2007–2008	967 829	24 295	2.5	6	0.247	270	201–367
2008–2009	1 565 517	91 358	5.8	9	0.099	392	293–530
2009–2010	1 247 437	80 009	6.4	20	0.25	455	319–663
2010–2011	1 646 656	87 730	5.3	15	0.171	444	312–650
2011–2012†	1 291 923	39 210	3.0	7	0.179	375	259–568
2012–2013	994 535	60 180	6.1	3	0.05	316	219–462

†Provisional data, model estimates not finalised.

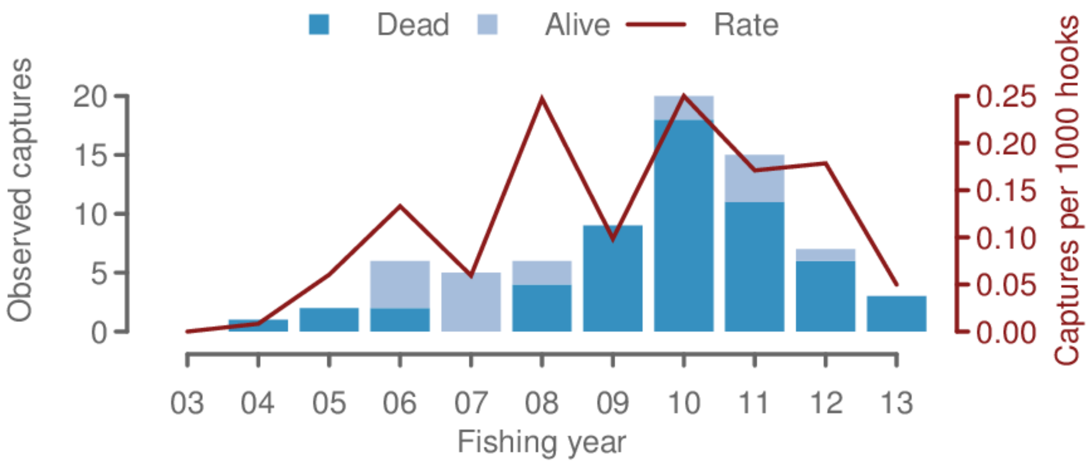


Figure 5: Observed captures of seabirds in bigeye tuna longline fisheries from 2002–03 to 2012–13.

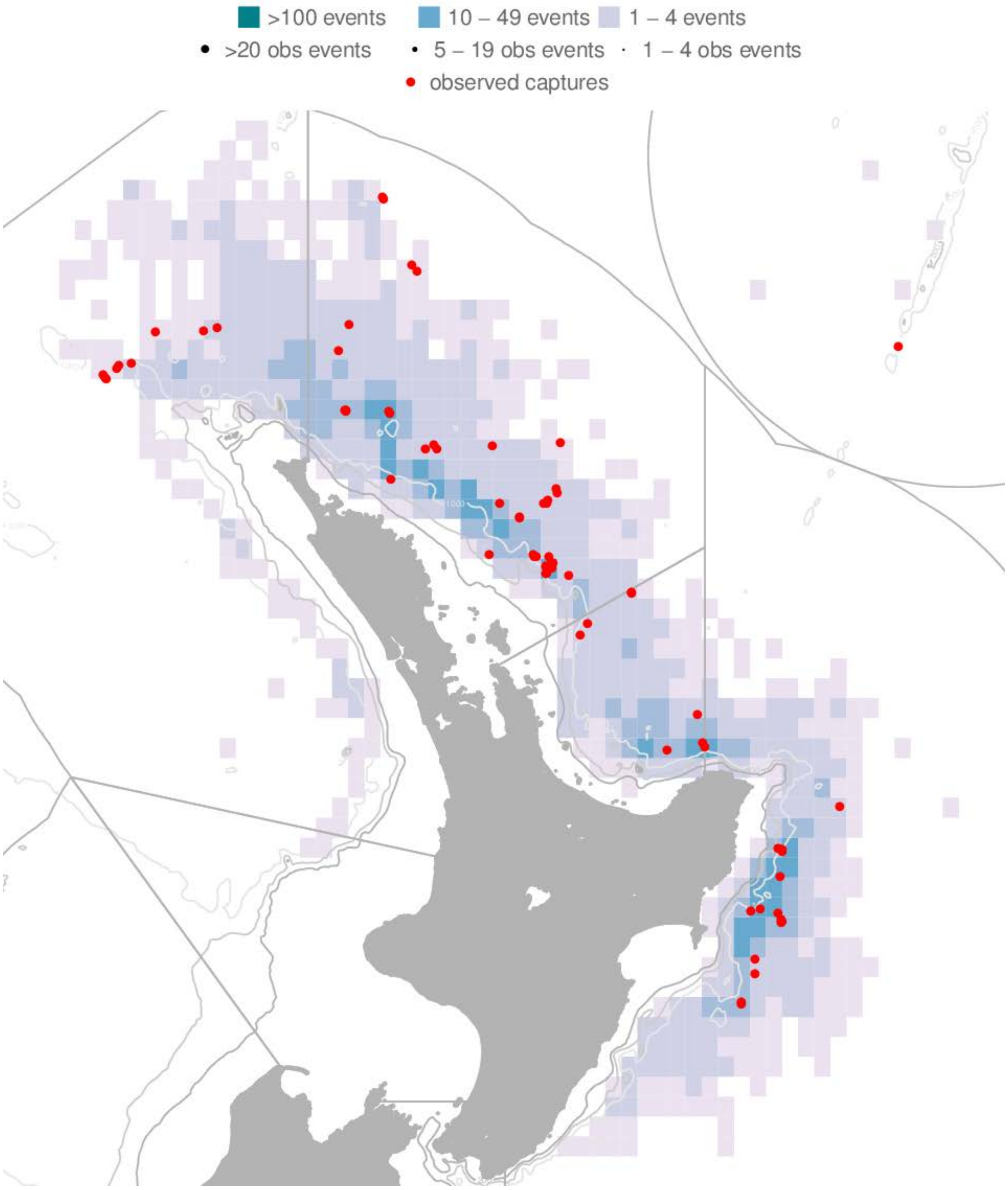


Figure 6: Distribution of fishing effort targeting bigeye tuna and observed seabird captures, 2002–03 to 2012–13. Fishing effort is mapped into 0.2-degree cells, with the colour of each cell being related to the amount of effort. Observed fishing events are indicated by black dots, and observed captures are indicated by red dots. Fishing is only shown if the effort could be assigned a latitude and longitude, and if there were three or more vessels fishing within a cell. In this case, 94.6% of the effort is shown. See glossary for areas used for summarising the fishing effort and protected species captures.

Table 7: Risk ratio of seabirds predicted by the level two risk assessment for the bigeye target surface longline fishery and all fisheries included in the level two risk assessment, 2006–07 to 2012–13, showing seabird species with risk category of very or high, or a medium risk category and risk ratio of at least 1% of the total risk. The risk ratio is an estimate of aggregate potential fatalities across trawl and longline fisheries relative to the Potential Biological Removals, PBR_1 (from Richard and Abraham 2014 where full details of the risk assessment approach can be found). PBR_1 applies a recovery factor of 1.0. Typically a recovery factor of 0.1 to 0.5 is applied (based on the state of the population) to allow for recovery from low population sizes as quickly as possible. This should be considered when interpreting these results. The New Zealand threat classifications are shown (Robertson et al 2013 at http://www.doc.govt.nz/documents/science-and-technical/nztcs4entire.pdf)

	Risk ratio				
Species name	BIG target SLL	Total risk from NZ commercial fishing	% of total risk from NZ commercial fishing	Risk category	NZ Threat Classification
Black petrel	0.886	15.095	5.87	Very high	Threatened: Nationally Vulnerable
Salvin's albatross	0.021	3.543	0.59	Very high	Threatened: Nationally Critical
Southern Buller's albatross	0.057	2.823	2.02	Very high	At Risk: Naturally Uncommon
Flesh-footed shearwater	0.077	1.557	4.91	Very high	Threatened: Nationally Vulnerable
Gibson's albatross	0.299	1.245	24.04	Very high	Threatened: Nationally Critical
New Zealand white-capped albatross	0.025	1.096	2.30	Very high	At Risk: Declining
Chatham Island albatross	0.000	0.913	0.00	High	At Risk: Naturally Uncommon
Antipodean albatross	0.207	0.888	23.33	High	Threatened: Nationally Critical
Westland petrel	0.040	0.498	7.95	High	At Risk: Naturally Uncommon
Northern Buller's albatross	0.190	0.336	56.70	High	At Risk: Naturally Uncommon
Campbell black-browed albatross	0.059	0.304	19.45	High	At Risk: Naturally Uncommon
Stewart Island shag	0.000	0.301	0.00	High	Threatened: Nationally Vulnerable
White-chinned petrel	0.008	0.268	2.90	Medium	At Risk: Declining
Northern royal albatross	0.009	0.181	5.12	Medium	At Risk: Naturally Uncommon

4.2.2 Sea turtle bycatch

Between 2002–03 and 2012–13, there were ten observed captures of turtles in bigeye tuna longline fisheries (Table 8 and Table 9). Observer recordings documented all sea turtles as captured and released alive. Sea turtle capture distributions are more common on the east coast of the North Island (Figure 8).

Table 8: Number of observed sea turtle captures in bigeye tuna longline fisheries, 2002–03 to 2012–13, by species and area. Data from Thompson et al (2013), retrieved from http://data.dragonfly.co.nz/psc/. See glossary above for a description of the areas used for summarising the fishing effort and protected species captures.

Species	East Coast North Island	Kermadec Islands	West Coast North Island	Total
Leatherback turtle	3	1	3	7
Unidentified turtle	1	0	2	3
Total	4	1	5	10

Table 9: Fishing effort and sea turtle captures in bigeye tuna longline fisheries by fishing year. For each fishing year, the table gives the total number of hooks; the number of observed hooks; observer coverage (the percentage of hooks that were observed); the number of observed captures (both dead and alive); and the capture rate (captures per thousand hooks). For more information on the methods used to prepare the data see Thompson et al (2013).

	Fishing effort			Observed captures	
Fishing year	All hooks	Observed hooks	% observed	Number	Rate
2002–2003	5 188 107	80 640	1.6	0	0
2003–2004	3 507 307	120 740	3.4	1	0.008
2004–2005	1 648 181	33 116	2	2	0.060
2005–2006	1 867 706	45 100	2.4	1	0.022
2006–2007	1 532 071	84 150	5.5	1	0.012
2007–2008	967 829	24 295	2.5	0	0
2008–2009	1 565 517	91 358	5.8	2	0.022
2009–2010	1 247 437	80 009	6.4	0	0
2010–2011	1 646 656	87 730	5.3	1	0.011
2011–2012	1 291 923	39 210	3.0	0	0
2012–2013	994 535	60 180	6.1	2	0.033

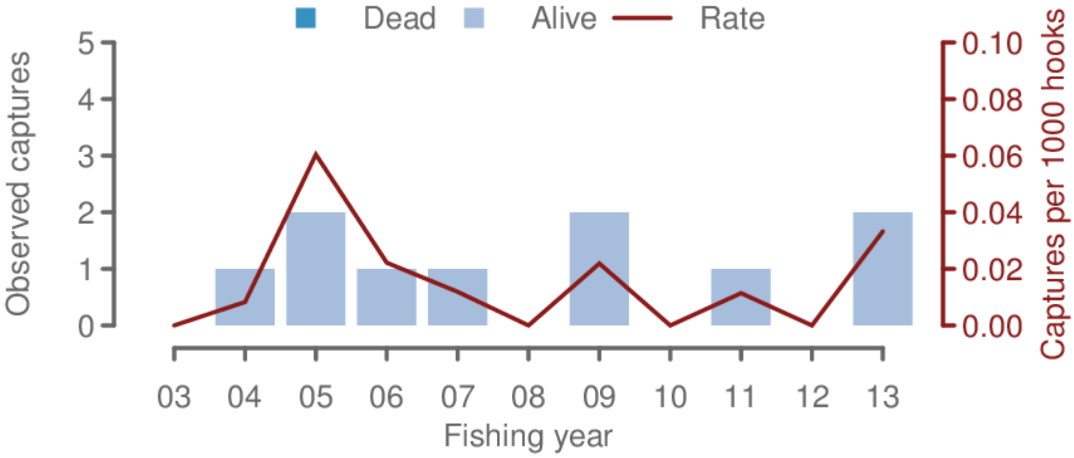


Figure 7: Observed captures of sea turtles in bigeye tuna longline fisheries from 2002–03 to 2012–13.

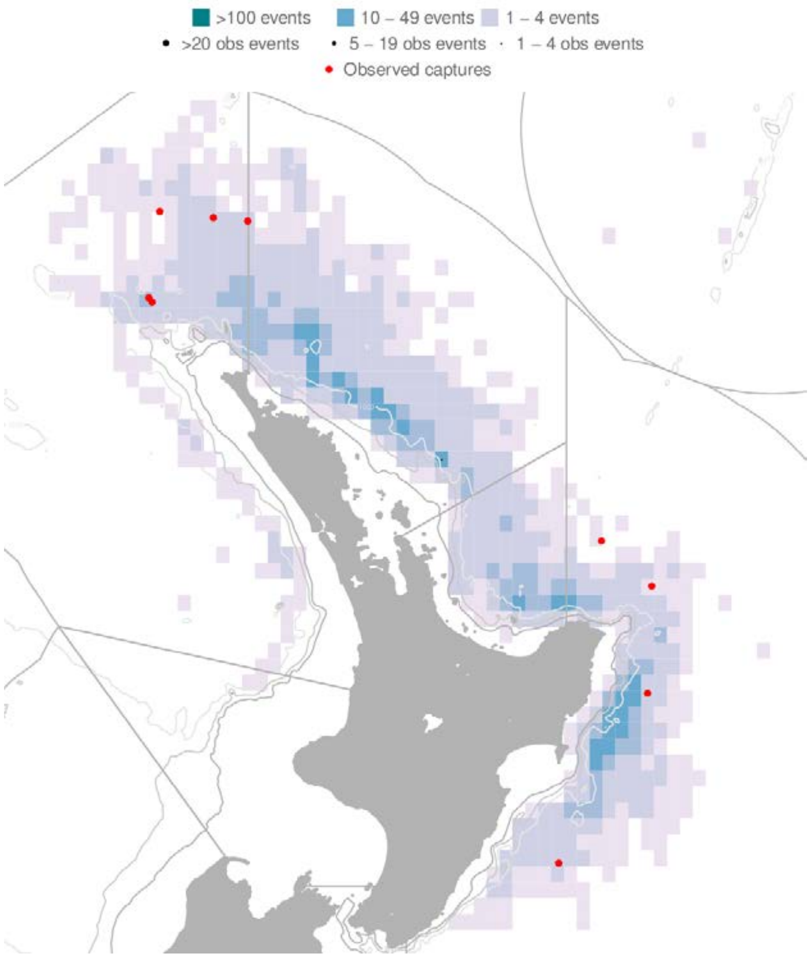


Figure 8: Distribution of fishing effort targeting bigeye tuna and observed sea turtle captures, 2002–03 to 2012–13. Fishing effort is mapped into 0.2-degree cells, with the colour of each cell being related to the amount of effort. Observed fishing events are indicated by black dots, and observed captures are indicated by red dots. Fishing is only shown if the effort could be assigned a latitude and longitude, and if there were three or more vessels fishing within a cell. In this case, 94.6% of the effort is shown. See glossary for areas used for summarising the fishing effort and protected species captures.

4.2.3 Marine Mammals

4.2.3.1 Cetaceans

Cetaceans are dispersed throughout New Zealand waters (Perrin et al 2008). The spatial and temporal overlap of commercial fishing grounds and cetacean foraging areas has resulted in cetacean captures in fishing gear (Abraham & Thompson 2009, 2011). The analytical methods used to estimate capture numbers across the commercial fisheries have depended on the quantity and quality of the data, in terms of the numbers observed captured and the representativeness of the observer coverage. Ratio estimation is used to calculate total captures in longline fisheries by target fishery fleet and area (Baird 2008) and by all fishing methods (Abraham et al 2010).

Between 2002–03 and 2012–13, there was one observed unidentified cetacean capture in bigeye longline fisheries (Tables 10 and 11). This capture took place on the west coast of the North Island (Figures 9 and 10) (Abraham & Thompson 2011). The captured animal recorded was documented as being caught and released alive (Thompson & Abraham 2010).

Table 10: Number of observed cetacean captures in bigeye tuna longline fisheries, 2002–03 to 2012–13, by species and area. Data from Thompson et al (2013), retrieved from http://data.dragonfly.co.nz/psc/. See glossary above for a description of the areas used for summarising the fishing effort and protected species captures.

Species	West Coast North Island	Total
Unidentified cetacean	1	1

Table 11: Effort and cetacean captures by fishing year in bigeye tuna fisheries. For each fishing year, the table gives the total number of hooks; the number of observed hooks; observer coverage (the percentage of hooks that were observed); the number of observed captures (both dead and alive); and the capture rate (captures per thousand hooks). For more information on the methods used to prepare the data, see Thompson et al (2013).

	Fishing effort			Observed captures	
Fishing year	All hooks	Observed hooks	% observed	Number	Rate
2002–2003	5 188 107	80 640	1.6	0	0
2003–2004	3 507 307	120 740	3.4	1	0.008
2004–2005	1 648 181	33 116	2	0	0
2005–2006	1 867 706	45 100	2.4	0	0
2006–2007	1 532 071	84 150	5.5	0	0
2007–2008	967 829	24 295	2.5	0	0
2008–2009	1 565 517	91 358	5.8	0	0
2009–2010	1 247 437	80 009	6.4	0	0
2010–2011	1 646 656	87 730	5.3	0	0
2011–2012	1 291 923	39 210	3.0	0	0
2012–2013	994 535	60 180	6.1	0	0

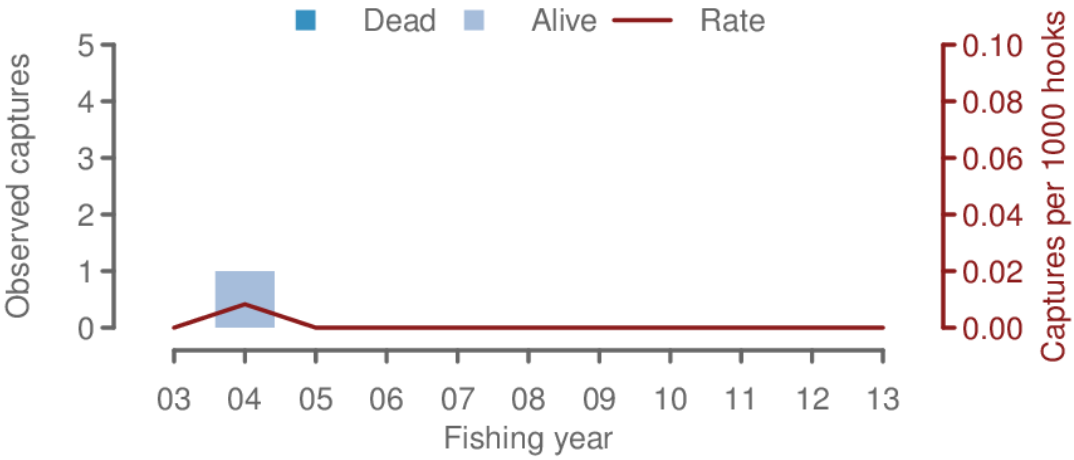


Figure 9: Observed captures of cetaceans in bigeye longline fisheries from 2002–03 to 2012–13.

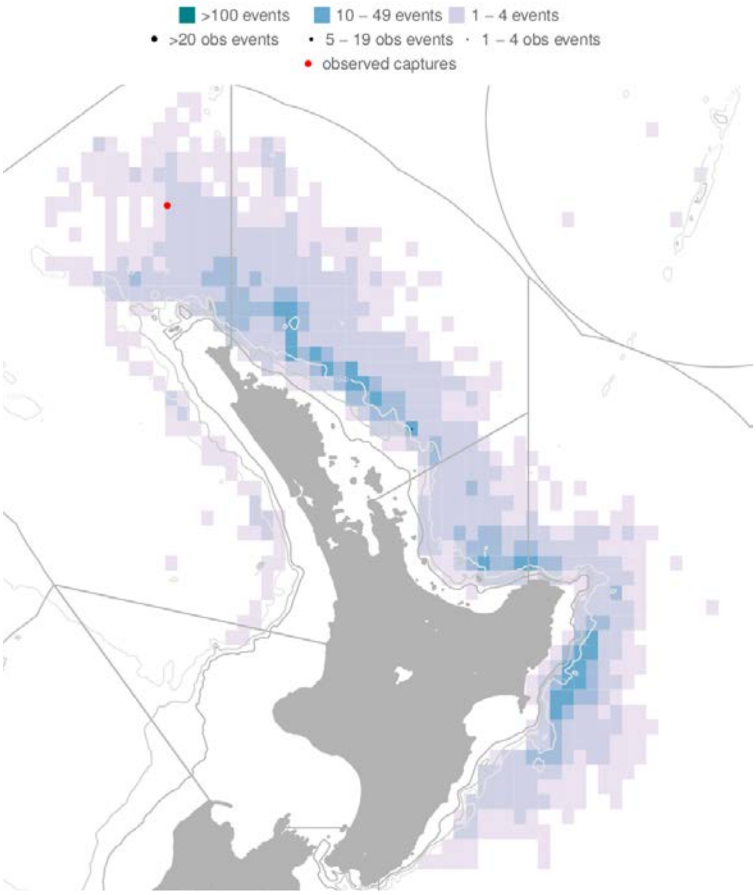


Figure 10: Distribution of fishing effort targeting bigeye tuna and observed cetacean captures, 2002–03 to 2012–13. Fishing effort is mapped into 0.2-degree cells, with the colour of each cell being related to the amount of effort. Observed fishing events are indicated by black dots, and observed captures are indicated by red dots. Fishing is only shown if the effort could be assigned a latitude and longitude, and if there were three or more vessels fishing within a cell. In this case, 94.6% of the effort is shown. See glossary for areas used for summarising the fishing effort and protected species captures.

4.2.4 New Zealand fur seal bycatch

Currently, New Zealand fur seals are dispersed throughout New Zealand waters, especially in waters south of about 40º S to Macquarie Island. The spatial and temporal overlap of commercial fishing grounds and New Zealand fur seal foraging areas has resulted in New Zealand fur seal captures in fishing gear (Mattlin 1987, Rowe 2009). Most fisheries with observed captures occur in waters over or close to the continental shelf, which slopes steeply to deeper waters relatively close to shore, and thus rookeries and haulouts, around much of the South Island and offshore islands. Captures on longlines occur when the fur seals attempt to feed on the bait and fish catch during hauling. Most New Zealand fur seals are released alive, typically with a hook and short snood or trace still attached.

The analytical methods used to estimate capture numbers across the commercial fisheries have depended on the quantity and quality of the data, in terms of the numbers observed captured and the representativeness of the observer coverage. New Zealand fur seal captures in surface longline fisheries have been generally observed in waters south and west of Fiordland, but also in the Bay of Plenty-East Cape area when the animals have attempted to take bait or fish from the line as it is hauled. These capture rates include animals that are released alive (100% of observed surface longline capture in 2008–09; Thompson & Abraham 2010). Between 2002–03 and 2012–13, there were two observed captures of New Zealand fur seals in bigeye longline fisheries (Tables 12 and 13, Figures 11 and 12).

Table 12: Number of observed New Zealand fur seal captures in bigeye tuna longline fisheries, 2002–03 to 2012–13, by species and area. Data from Thompson et al (2013), retrieved from http://data.dragonfly.co.nz/psc/. See glossary above for a description of the areas used for summarising the fishing effort and protected species captures.

	West Coast North Island	Total
New Zealand fur seal	2	2

Table 13: Effort and captures of New Zealand fur seal by fishing year in bigeye tuna longline fisheries. For each fishing year, the table gives the total number of hooks; the number of observed hooks; observer coverage (the percentage of hooks that were observed); the number of observed captures (both dead and alive); and the capture rate (captures per thousand hooks). Estimates are based on methods described in Thompson et al (2013) are available via http://www.fish.govt.nz/en-nz/Environmental/Seabirds/. Estimates from 2002–03 to 2010–11 and preliminary estimates for 2012–13 are based on data version 20140131.

	Fishing effort			Observed captures		Estimated captures	
Fishing year	All hooks	Observed hooks	% observed	Number	Rate	Mean	95% c.i.
2002–2003	5 188 107	80 640	1.6	0	0	24	3–67
2003–2004	3 507 307	120 740	3.4	0	0	8	1–24
2004–2005	1 648 181	33 116	2	0	0	4	0–11
2005–2006	1 867 706	45 100	2.4	0	0	3	0–10
2006–2007	1 532 071	84 150	5.5	0	0	1	0–6
2007–2008	967 829	24 295	2.5	2	0.082	2	0–8
2008–2009	1 565 517	91 358	5.8	0	0	4	0–11
2009–2010	1 247 437	80 009	6.4	0	0	3	0–11
2010–2011	1 646 656	87 730	5.3	0	0	5	0–15
2011–2012	1 291 923	39 210	3.0	0	0	7	1–20
2012–2013†	994 535	60 180	6.1	0	0	4	0–13

†Provisional data, model estimates not finalised.

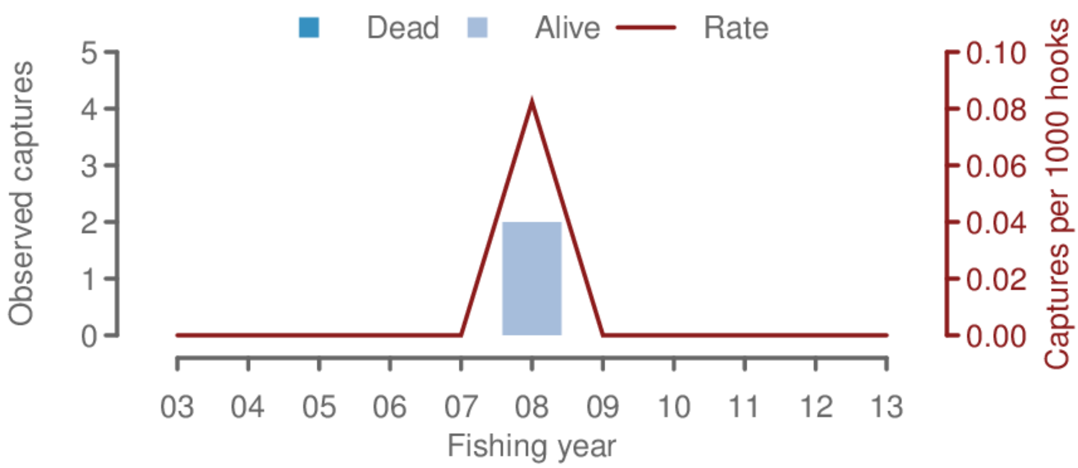


Figure 11: Observed captures of New Zealand fur seal in bigeye tuna longline fisheries from 2002-03 to 2012-13 **[Continued on next page].**

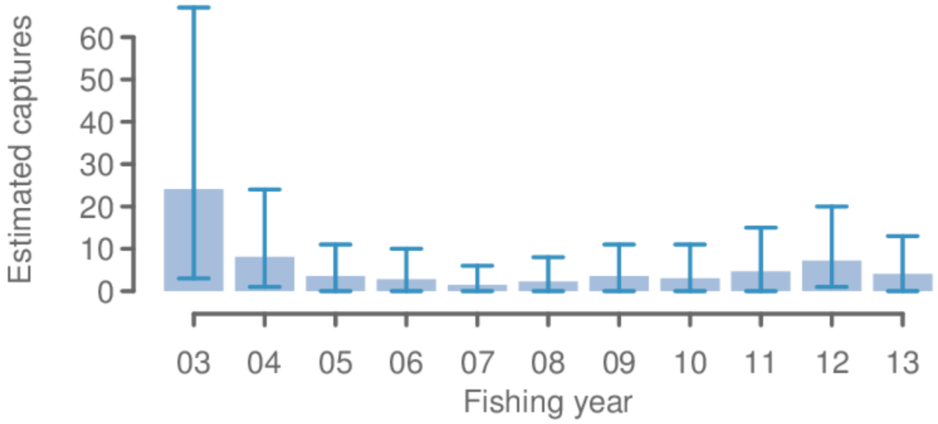


Figure 11 [Continued]: Estimated captures of New Zealand fur seal in bigeye tuna longline fisheries from 2002-03 to 2012-13.

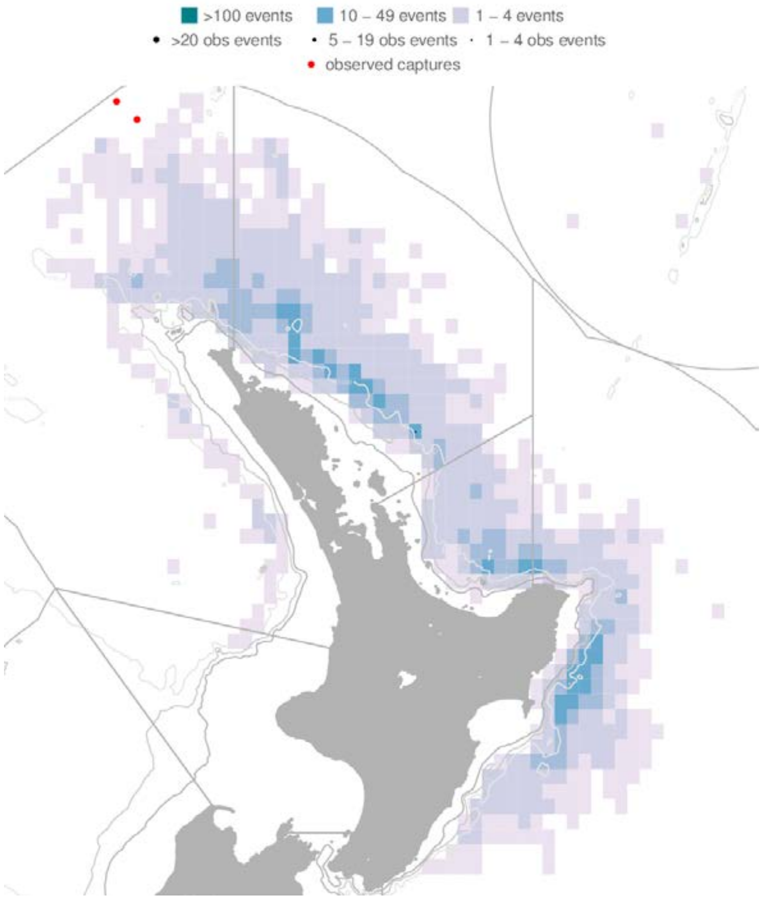


Figure 12: Distribution of fishing effort targeting bigeye tuna and observed New Zealand fur seal captures, 2002–03 to 2012–13. Fishing effort is mapped into 0.2-degree cells, with the colour of each cell being related to the amount of effort. Observed fishing events are indicated by black dots, and observed captures are indicated by red dots. Fishing is only shown if the effort could be assigned a latitude and longitude, and if there were three or more vessels fishing within a cell. In this case, 94.6% of the effort is shown. See glossary for areas used for summarising the fishing effort and protected species captures.

4.3 Incidental fish bycatch

Observer records indicate that a wide range of species are landed by the longline fleets in New Zealand fishery waters. Blue sharks are the most commonly landed species (by number), followed by Ray's bream (Table 14). Southern bluefin tuna and albacore tuna are the only target species that occur in the top five of the frequency of occurrence.

Table 14: Total estimated catch (numbers of fish) of common bycatch species in the New Zealand longline fishery as estimated from observer data from 2009 to 2013. Also provided is the percentage of these species retained (2013 data only) and the percentage of fish that were alive when discarded, N/A (none discarded).

Species	2010	2011	2012	2013	% retained (2013)	discards % alive (2013)
Blue shark	66113	53432	132925	158736	45.2	97.4
Lancetfish	43425	37305	7866	19172	0.1	37.6
Rays bream	20041	18453	19918	13568	97.4	4.2
Porbeagle shark	4679	9929	7019	9805	34.0	79.8
Mako shark	4490	9770	3902	3981	35.5	84.9
Moonfish	5398	3418	2363	2470	99.0	0.0
Escolar	1539	6602	2181	2088	30.2	76.3
Sunfish	3148	3773	3265	1937	2.7	100.0
Pelagic stingray	1983	4090	712	1199	1.0	97.0
Butterfly tuna	1158	909	713	1030	48.1	11.1
Deepwater dogfish	377	548	647	743	1.2	88.5
Oilfish	886	1747	509	386	26.5	72.2
Rudderfish	326	338	491	362	13.0	80.0
Thresher shark	209	349	246	256	33.3	75.0
Skipjack tuna	91	255	123	240	100.0	N/A
Dealfish	1160	223	372	237	1.7	25.1
Striped marlin	471	175	124	182	0.0	44.4
Big scale pomfret	505	139	108	67	88.2	100.0
School shark	62	49	477	21	100.0	N/A

4.4 Benthic interactions
N/A

4.5 Key environmental and ecosystem information gaps
Cryptic mortality is unknown at present but developing a better understanding of this in future may be useful for reducing uncertainty of the seabird risk assessment and could be a useful input into risk assessments for other species groups.

The survival rates of released target and bycatch species is currently unknown.

Observer coverage in the New Zealand fleet is not spatially and temporally representative of the fishing effort.

5. STOCK ASSESSMENT

With the establishment of the WCPFC in 2004, future stock assessments of the WCPO stock of bigeye tuna are undertaken by the Oceanic Fisheries Programme (OFP) of Secretariat of the Pacific Community under contract to WCPFC. As noted above, there is continuing work on a Pacific-wide bigeye assessment.

No assessment is possible for bigeye within the New Zealand EEZ as the proportion of the total stock found within New Zealand fisheries waters is unknown and is likely to vary from year to year.

The bigeye stock assessment was updated by the SPC in 2014 in SC10-SA-WP-01 (Harley et. al. 2014a) and reviewed by the WCPFC Scientific Committee (SC10) in August 2014. In addition SC10-SA-IP-01 (Harley et. al. 2014b) summarized the major changes to the tropical tuna stock assessments resulting from the recommendations provided in SC8-SA-WP-01 (Independent Review of the 2011 bigeye tuna stock assessment). Also, status quo stochastic projections were provided for bigeye tuna in SC10-SA-WP-06 (Pilling 2014).

The following is a summary of the 2014 bigeye stock assessment as agreed by the WCPFC Scientific Committee (SC10) in August 2014.

Some of the main improvements in the 2014 assessment are:

- Increases in the number of spatial regions to better model the tagging and size data;
- Inclusion of catch estimates from Vietnam and some Japanese coastal longline data previously not included;
- The use of operational longline data for multiple fleets to better address the contraction of the Japanese fleet and general changes over time in targeting practices;
- Improved modelling of recruitment to ensure that uncertain estimates do not influence key stock status outcomes; and
- A large amount of new tagging data corrected for differential post-release mortality and other tag losses

The large number of changes since the 2011 assessment (some of which are described above), and the nature of some of those changes, means that full consideration of the impacts of individual changes is not possible. Nevertheless, the report details some of the key steps from the 2011 reference case (Run3j – Ref.case) to the 2014 reference case (037_L0W0T0M0H0). Distinguishing features of the 2014 reference case model include:

- The steepness parameter of the stock recruitment relationship is fixed at 0.8.
- The mean length of the oldest age class in the model is fixed at 184 cm.
- Natural mortality at age is fixed according to an external analysis in which it is assumed that the natural mortality rate of females increases with the onset of reproductive maturity.
- The likelihood function weighting of the size data is determined using an effective sample size for each fishing observation of one-twentieth of the actual sample size, with a maximum effective sample size of 50.
- For modelling the tagging data, a mixing period of 2 quarters (including the quarter of release) is applied.
- The last six quarterly recruitments aggregated over regions are assumed to lie on the stock-recruitment curve.

The rationale for these choices, which comprise the key areas of uncertainty for the assessment, is described in detail in SC10-SA-WP-01. We report the results of “one-off” sensitivity models to explore the impact of these choices for the reference case model on the stock assessment results. A sub-set of key, plausible model runs was taken from these sensitivities to include in a structural uncertainty analysis (grid) for consideration in developing management advice.

The main conclusions of the current assessment are consistent with recent assessments presented in 2010 and 2011. The main conclusions based on the results from the reference case model and with consideration of results from performed sensitivity model runs, are as follows:

1) The new regional structure, modelling and data improvements appear to have improved the current assessment with the previously observed increasing trend in recruitment much reduced and the fit to Coral Sea tagging data greatly improved.

2) Nevertheless there is some confounding between estimated growth, regional recruitment distributions and movement which, while having minimal impact on stock status conclusions, lead to a complex solution surface and the presence of local minima.

3) Current catches exceed maximum sustainable yield (MSY);

4) Recent levels of fishing mortality exceed the level that will support the MSY;

5) Recent levels of spawning potential are most likely at (based on 2008-11 average) or below (based on 2012) the level which will support the MSY;

6) Recent levels of spawning potential are most likely at (based on 2008-11 average) or below (based on 2012) the LRP of 20%$SB_{F=0}$ agreed by WCPFC;

7) Recent levels of spawning potential are lower than candidate biomass-related target reference points (TRPs) currently under consideration for skipjack tuna, i.e., 40-60% $SB_{F=0}$; and

8) Stock status conclusions were most sensitive to alternative assumptions regarding the modelling of tagging data and the longline CPUE series included, identifying these as important areas for continued research. However, the main conclusions of the assessment are robust to the range of uncertainty that was explored.

Paper SC10-SA-WP-06 (Pilling 2014) contained status quo stochastic projections for bigeye, skipjack, and yellowfin tunas. The paper outlined an assessment of the potential consequences of recent (2012) fishing conditions on the future biological status of the three tropical tuna stocks, based on the 2014 tropical tuna stock assessments. Projected status in 2032 was reported relative to spawning biomass and fishing mortality reference levels in absolute terms (as a median of the projection outcomes) and in probabilistic terms.

A single assessment model run (the reference case model for each tropical tuna stock) was used as the basis for projecting future stock status. Only uncertainty arising from future recruitment conditions was therefore captured in the results, using two alternative hypotheses: where recruitment was assumed to follow the estimated stock recruitment relationship on average with randomly selected deviates from the period used to estimate the relationship in each stock assessment; or was assumed to be consistent with actual recruitments estimated over the period 2002-2011.

Under 2012 conditions, stochastic projection results indicated bigeye tuna were dependent upon the recruitment assumption, the stock was either very likely (>90%; long-term recruitment deviate assumption) or unlikely (<25%; recent recruitment assumption) to fall below both the LRP and SB_{MSY} levels by 2032. Under both recruitment assumptions, it was virtually certain (>99%) that fishing mortality would be above the F_{MSY} level in 2032.

Stock status and trends

There have been significant improvements to the 2014 stock assessment resulting from the implementation of the 2012 bigeye review recommendations. Improvements were made to regional and fisheries structures, CPUE, size, and tagging data inputs, and the MULTIFAN-CL modelling framework. This assessment is also the first since the adoption of a LRP based on the spawning biomass in the absence of fishing (0.2$SB_{F=0}$).

SC10 selected the reference case model as the base case to represent the stock status of bigeye. To characterize uncertainty SC10 chose three additional models based on alternative values of steepness and a shorter tag mixing period. Details of the base case and other models are provided in Table 15.

Table 15: Description of the base case and key model chosen for the provision of management advice.

Name	Description
Base Case	JP CPUE for regions 1, 2, and 4, all flags for regions 3, 7, 8, 5, and 6, and nominal for region 9. Size data weighted as the weighted number of samples divided by 20, steepness fixed at 0.8, M fixed, tag mixing at 2 quarters, and the mean length of fish in the oldest age class (L2) fixed at 184 cm.
h_0.65	Steepness=0.65.
h_0.95	Steepness=0.95.
Mix_1qtr	Tag mixing period=1 quarter

Time trends in estimated recruitment, biomass, fishing mortality and depletion are shown in Figures 13-16.

The estimated maximum sustainable yield (MSY) of 108,520 mt is higher than previous assessments. This is for three key reasons 1) the improved assessment has higher average recruitment; 2) application of the lognormal bias correction to the spawner-recruitment relationship; and 3) increased catches used in the new assessment.

Fishing mortality has generally been increasing through time, and for the reference case $F_{current}$ (2008-11 average) is estimated to be 1.57 times the fishing mortality that will support the *MSY*. Across the four models (base case and three sensitivity models) $F_{current}/F_{MSY}$ ranged from 1.27 to 1.95. This indicates that overfishing is occurring for the WCPO bigeye tuna stock and that in order to reduce fishing mortality to F_{MSY} levels the base case indicates that a 36% reduction in fishing mortality is required from 2008–2011 levels (Table 16 and Figure 15). This is similar to the 32% reduction from 2006-2009 levels recommended from the 2011 assessment.

The latest (2012) estimates of spawning biomass are below both the level that will support the MSY (SB_{latest}/SB_{MSY} = 0.77 for the base case and range 0.62-0.96 across the four models) and the newly adopted LRP of $0.2SB_{F=0}$ ($SB_{latest}/SB_{F=0}$ = 0.16 for the base case and range 0.14-0.18).

An analysis of historical patterns in the mix of fishing gear types indicates that MSY has been reduced to less than half its level prior to 1970 through the increased harvesting of juveniles (Figure 16).

Table 16: Estimates of management quantities for selected stock assessment models (see Table BET1 for details). For the purpose of this assessment, "current" is the average over the period 2008–2011 and "latest" is 2012.

	Base case	h=0.65	h=0.95	Mix_1qtr
MSY(mt)	108,520	101,880	116,240	107,880
C_{latest}/MSY	1.45	1.55	1.36	1.45
$F_{current}/F_{MSY}$	1.57	1.95	1.27	1.73
B_0	2,286,000	2,497,000	2,166,000	2,183,000
$B_{current}$	742,967	744,596	741,549	640,645
SB_0	1,207,000	1,318,000	1,143,000	1,153,000
SB_{MSY}	345,400	429,900	275,200	328,700
$SB_{F=0}$	1,613,855	1,848,385	1,483,216	1,585,331
SB_{curr}	325,063	326,007	324,283	269,820
SB_{latest}	265,599	266,290	264,937	218,679
$SB_{curr}/SB_{F=0}$	0.20	0.18	0.22	0.17
$SB_{latest}/SB_{F=0}$	0.16	0.14	0.18	0.14
SB_{curr}/SB_{MSY}	0.94	0.76	1.18	0.82
SB_{latest}/SB_{MSY}	0.77	0.62	0.96	0.67

Table 17: Comparison of selected WCPO bigeye tuna reference points from the 2010, 2011, and 2012 base case models.

Management quantity	Base case 2010	Base case 2011	Base case 2014
MSY(mt)	73,840	76,760	108,520
$F_{current}/F_{MSY}$	1.41	1.46	1.57
$SB_{latest}/SB_{F=0}$	0.16	0.21	0.16

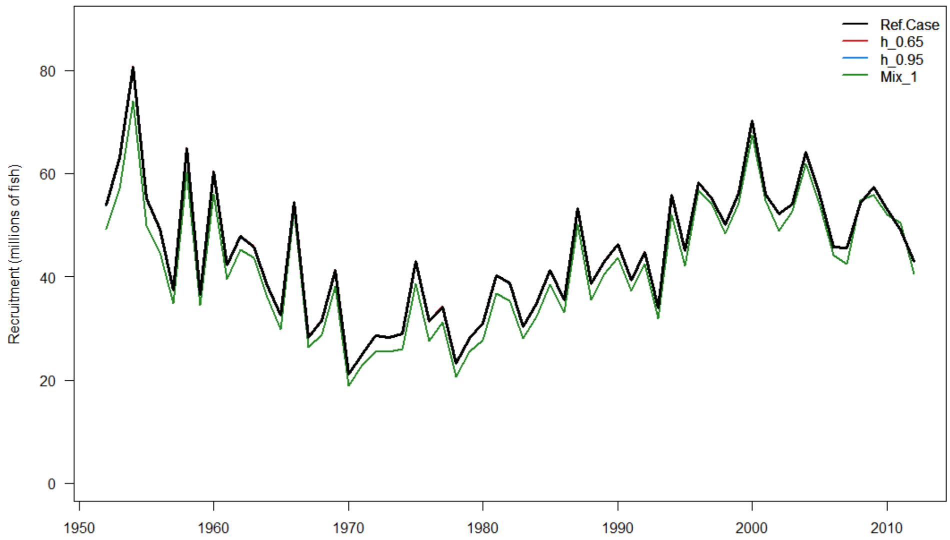


Figure 13: Estimated annual recruitment (millions of fish) for the WCPO obtained from the base case model from the base case model and three additional runs described in Table BET1. The model runs with alternative steepness values give the same recruitment estimates.

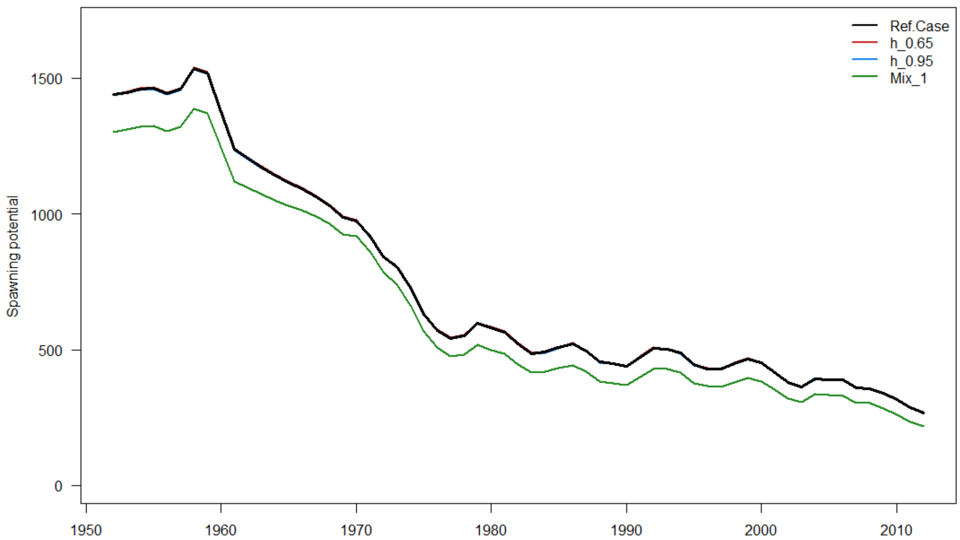


Figure 14: Estimated annual average spawning potential for the WCPO obtained from the base case model and three additional runs described in Table BET1. The model runs with alternative steepness values give the same spawning potential trajectory estimates as the reference case.

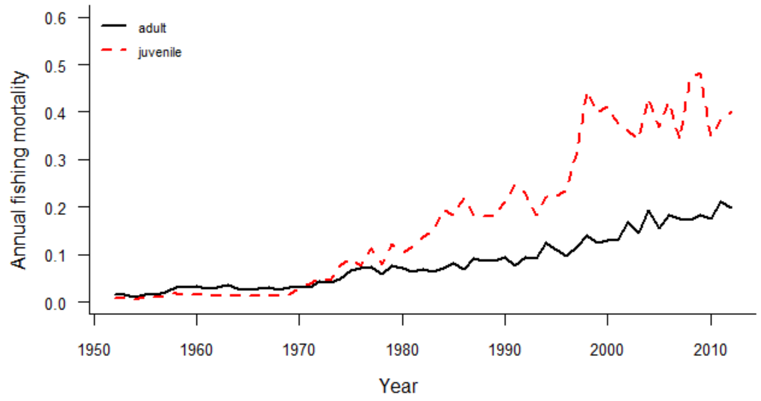


Figure 15: Estimated annual average juvenile and adult fishing mortality for the WCPO obtained from the base case model.

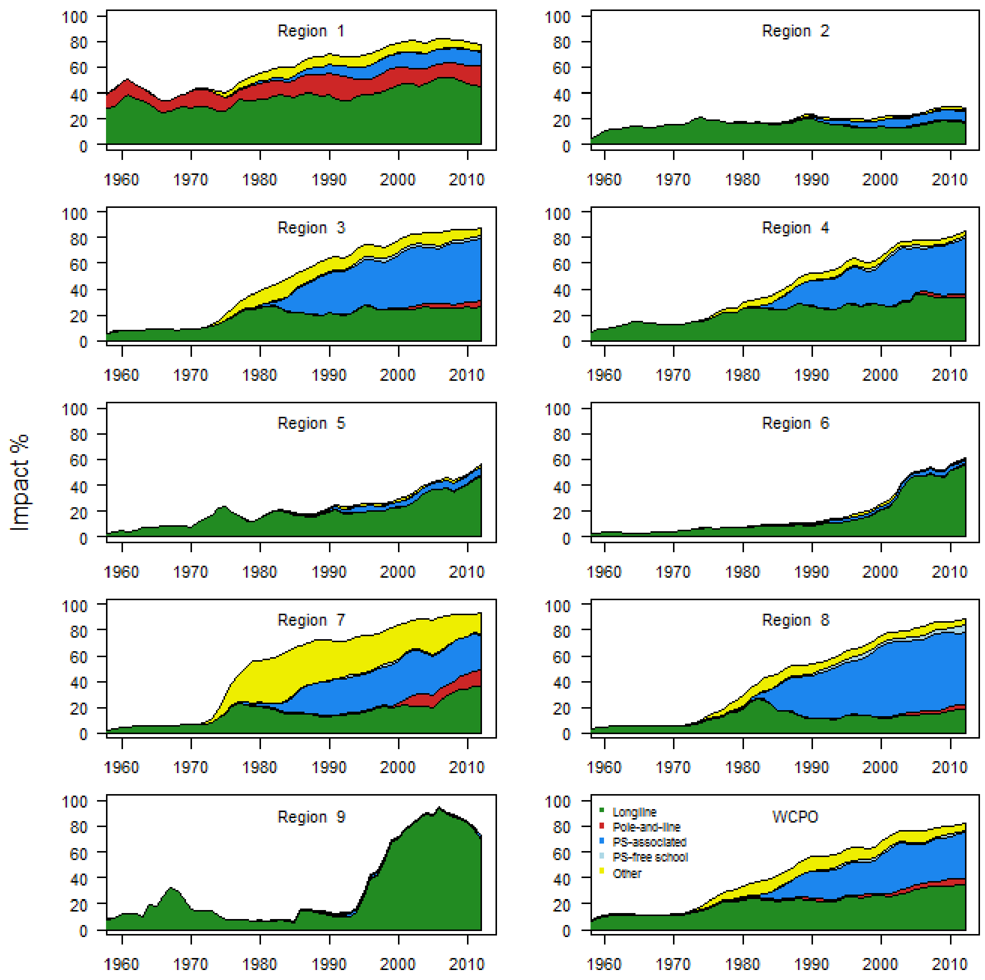


Figure 16: Estimates of reduction in spawning potential due to fishing (fishery impact = 1-$SB_t/SB_{t,F=0}$) by region and for the WCPO attributed to various fishery groups for the base case model.

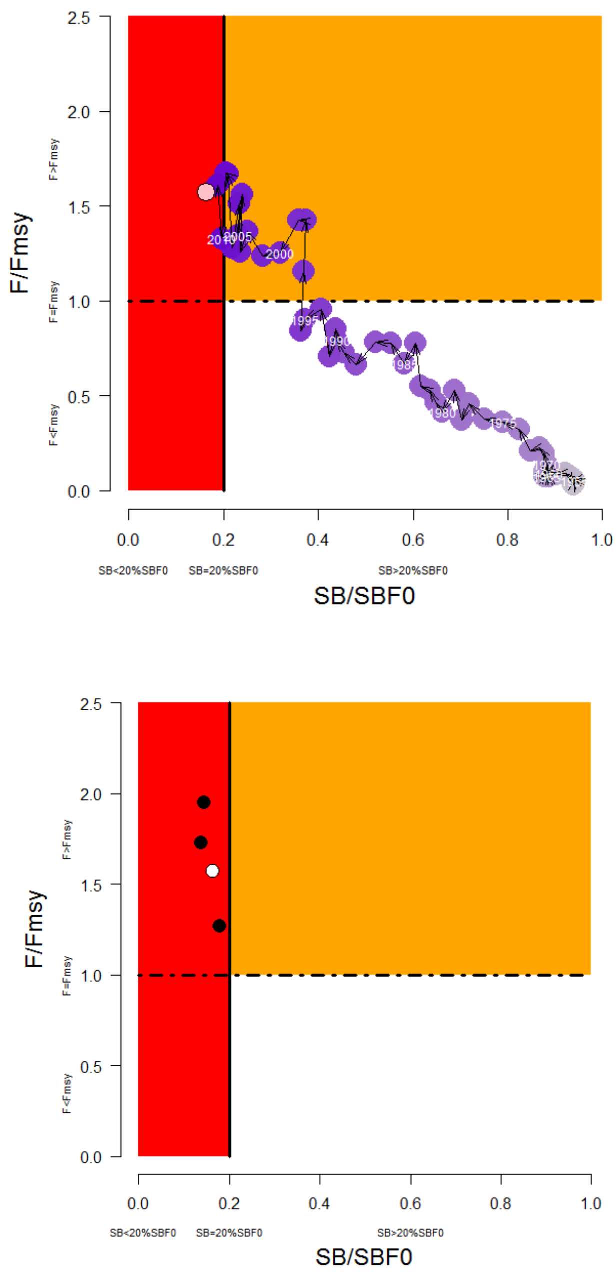


Figure 17: Temporal trend for the base case model (top) and terminal condition for the base case and other sensitivity runs (bottom) in stock status relative to $SB_{F=0}$ (x-axis) and F_{MSY} (y-axis). The red zone represents spawning potential levels lower than the agreed LRP which is marked with the solid black line ($0.2SB_{F=0}$). The orange region is for fishing mortality greater than F_{MSY} ($F=F_{MSY}$; marked with the black dashed line). The pink circle (top panel) is $SB_{2012}/SB_{F=0}$ (where $SB_{F=0}$ was the average over the period 2002-2011). The bottom panel includes the base case (white dot) and sensitivity analyses described Table BET-1.

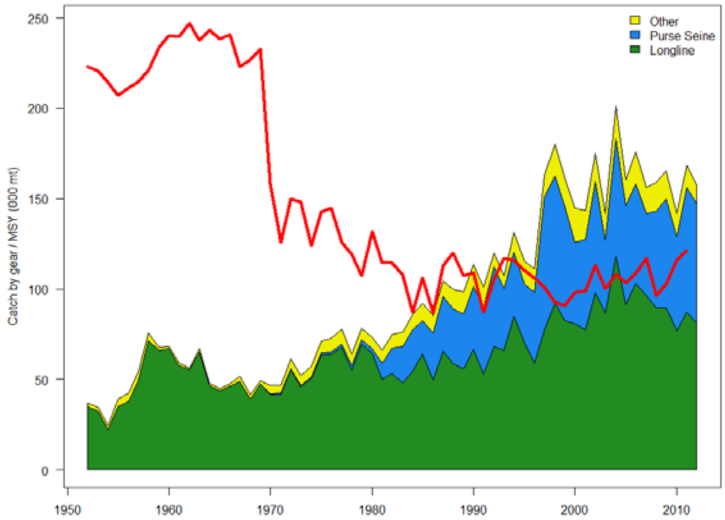


Figure 18: History of annual estimates of MSY compared with catches of three major fisheries for the base case model.

Management advice and implications

SC10 noted that the spawning biomass of WCPO bigeye tuna breached the biomass LRP in 2012 and that the stock was overfished. Rebuilding spawning biomass to be above the biomass LRP will require a reduction in fishing mortality.

SC10 recommended that fishing mortality on WCPO bigeye tuna be reduced. A 36% reduction in fishing mortality from the average levels for 2008–2011 would be expected to return the fishing mortality rate to F_{MSY}. This reduction of at least 36% should also allow the stock to rebuild above the LRP over a period of time. This recommended level of reduction in fishing mortality could also be stated as a minimum 33% reduction from the 2004 level of fishing mortality, or a minimum 26% reduction from the average 2001-2004 level of fishing mortality.

Future status quo projections (assuming 2012 conditions) depend upon assumptions on future recruitment. When spawner-recruitment relationship conditions are assumed, spawning biomass continues to decline and the stock is very likely (94%) to remain below the LRP based on projections through 2032 ($SB_{2032}<0.2SB_{F=0}$). If recent (2002-2011) actual recruitments are assumed, spawning biomass increases and it was unlikely (13%) to remain below the LRP. Under both recruitment assumptions, it was virtually certain (100%) that the stock would remain subject to overfishing ($F>F_{MSY}$).

Overfishing and the increase in juvenile bigeye catches have resulted in a considerable reduction in the potential yield of the WCPO bigeye stock. The loss in yield per recruit due to excess harvest of juvenile fish is substantial. SC10 concluded that MSY levels would increase if the mortality of juvenile bigeye was reduced.

Fishing mortality varies spatially within the Convention Area with high mortality in the tropical Pacific Ocean. WCPFC could consider a spatial management approach in reducing fishing mortality for bigeye tuna.

Considering the unavailability of operational longline data for the assessment from some key fleets, SC10 recommended that all operational data including high seas should be available for future stock assessments. The current lack of operational data for some fleets, and in particular the lack of operational longline data on the high seas hampered the 2014 assessment in a number of ways (e.g.

the construction of abundance indices) and consequently hindered the SC from achieving "best practice" in the 2014 stock assessment.

SC10 noted that arrangements are being developed between CCMs and SPC to facilitate the availability of operational data for the Pacific wide bigeye stock assessment scheduled for 2015 (Attachment F).

SC10 recommended that the Commission consider the results of updated projections at WCPFC11, including evaluation of the potential impacts of CMM 2013-01, to determine whether the CMM will achieve its objectives and allow the bigeye stock to rebuild above the LRP.

5.1 Estimates of fishery parameters and abundance

There are no fishery independent indices of abundance for the bigeye stock. Relative abundance information is available from longline catch per unit effort data, though there is no agreement on the best method to standardise these data and several methods are compared. Returns from a large scale tagging programme undertaken in the early 1990s, and an updated programme from 2007–2009 undertaken by the SPC provide information on rates of fishing mortality which in turn has improved estimates of abundance.

5.2 Biomass estimates

The stock assessment results and conclusions of the 2014 assessment show $SB_{current}$ / SB_{MSY} estimated at 0.94 over the period 2008-2011. This estimate applies to the WCPO portion of the stock or an area that is approximately equivalent to the waters west of 150°W. Spawning biomass for the WCPO is estimated to have declined to about 16% of its initial level by 2012.

5.3 Yield estimates and projections

No estimates of *MCY* and *CAY* are available.

5.4 Other yield estimates and stock assessment results

SC10 achieved consensus to accept and endorse the reference case proposed in the assessment document, and that $SB_{20\%,F=0}$ be used as the LRP for stock status purposes as agreed by WCPFC. There was further discussion about whether to use SB_{latest} or $SB_{current}$ as the terminal spawning biomass for management purposes. The SC agreed to use the most recent information on bigeye tuna spawning biomass, SB_{latest} corresponding to 2012, given recent trends of increasing catch, high fishing mortality and decreasing CPUE.

SC10 also endorsed the use of the candidate biomass-related target reference point (TRP) currently under consideration for skipjack tuna, i.e., 40-60% $SB_{F=0}$. At 0.16 $SB_{F=0}$ SB_{latest} is below both the target and limit reference points.

5.5 Other factors

There are three areas of concern with the bigeye stock:

- juveniles occur in mixed schools with small yellowfin and also with skipjack tunas throughout the equatorial Pacific Ocean. As a result, they are vulnerable to large-scale purse seine fishing, particularly when fish aggregating devices (FADs) are set on. Catches of juveniles can be a very high proportion of total removals in numbers from the stock;
- Overfishing and the increase in juvenile bigeye catches have resulted in a considerable reduction in the potential yield of the WCPO bigeye stock. The loss in yield per recruit due to excess harvest of juvenile fish is substantial. SC10 concluded that MSY levels would increase if the mortality of juvenile bigeye was reduced.

- Fishing mortality varies spatially within the Convention Area with high mortality in the tropical Pacific Ocean. WCPFC could consider a spatial management approach in reducing fishing mortality for bigeye tuna.

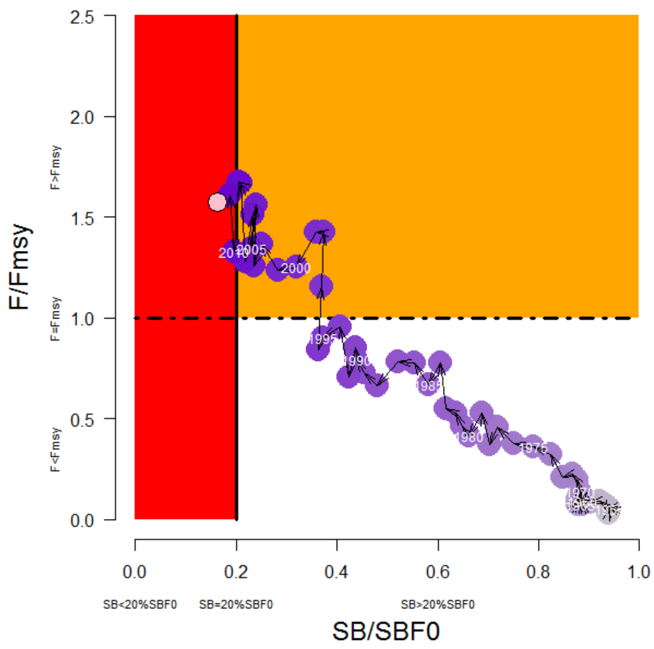
6. STATUS OF THE STOCKS

Stock structure assumptions

Western and Central Pacific Ocean
All estimates of biomass in this table refer to spawning biomass (SB).

Stock Status	
Year of Most Recent Assessment	A full stock assessment was conducted in 2014.
Assessment Runs Presented	Base case model and selected sensitivity analyses
Reference Points	Candidate biomass-related target reference point (TRP) currently under consideration for key tuna stocks is 40-60% SB_0 Limit reference point of 20% SB_0 established by WCPFC equivalent to the HSS default of 20% SB_0 Hard Limit: Not established by WCPFC; but evaluated using HSS default of 10% SB_0 Overfishing threshold: F_{MSY}
Status in relation to Target	Recent levels of spawning biomass (either the 2008-11 average or the 2012 estimate) are Very Unlikely (< 10%) to be at or above 40-60% SB_0 Very Unlikely (< 10%) that F < F_{MSY}
Status in relation to Limits	Soft Limit: Likely (> 60%) to be below Hard Limit: Unlikely (< 40%) to be below
Status in relation to Overfishing	Overfishing is Very Likely (> 90%) to be occurring

Historical Stock Status Trajectory and Current Status



Temporal trend for the base case model in stock status relative to $SB_{F=0}$ (x-axis) and F_{MSY} (y-axis). The red zone represents spawning biomass levels lower than the agreed LRP which is marked with the solid black line ($0.2SB_{F=0}$). The orange region is for fishing mortality greater than F_{MSY} ($F=F_{MSY}$; marked with the black dashed line). The pink circle is $SB_{2012}/SB_{F=0}$ (where $SB_{F=0}$ was the average over the period 2002-2011).

Fishery and Stock Trends	
Recent Trend in Biomass or	Biomass has decreased consistently since the 1950s to levels

Proxy	below SB_{MSY} in recent years. Spawning biomass for the WCPO is estimated to have declined to about half of the initial levels by about 1970, and has continued to decline (SB_{2012}/SB_0 = 0.16).
Recent Trend in Fishing Intensity or Proxy	Fishing mortality has generally increased and has recently escalated to levels near or above F_{2012}/F_{MSY} = 1.57.
Other Abundance Indices	-
Trends in Other Relevant Indicator or Variables	Recruitment in all analyses was estimated to have been high during the last two decades. This result is similar to that of previous assessments, and appears to be partly driven by conflicts between some of the CPUE, catch, and size data inputs.

Projections and Prognosis	
Stock Projections or Prognosis	Stochastic projection results were dependent upon the recruitment assumption. Under the long-term recruitment deviate assumption, the stock was Very Likely (> 90%) to be below both the LRP and SB_{MSY} levels by 2032; under the recent recruitment assumption, the stock was Unlikely (< 40%) to be below both the LRP and SB_{MSY} levels by 2032.
Probability of Current Catch or TACC causing Biomass to remain below or to decline below Limits	Under the long-term recruitment deviate assumption, the stock was Very Likely (> 90%) to be below the LRP in 2032; under the recent recruitment assumption, the stock was Unlikely (< 40%) to be below the LRP in 2032.
Probability of Current Catch or TACC causing Overfishing to continue or to commence	Under both recruitment assumptions, it was Virtually Certain (> 99%) that fishing mortality would be above the F_{MSY} level in 2032.

Assessment Methodology and Evaluation		
Assessment Type	Level 1- Quantitative Stock Assessment	
Assessment Method	The assessment uses the stock assessment model and computer software known as MULTIFAN-CL.	
Assessment Dates	Latest assessment: 2014	Next assessment: 2017
Overall assessment quality rank	1 - High Quality	
Main data inputs (rank)	- Catch and effort data - Size data - Growth data; and - Tagging data	1 - High Quality 1 - High Quality 1 - High Quality
Data not used (rank)	N/A	
Changes to Model Structure and Assumptions	Changes to the data from the 2011 assessment included: • Increases in the number of spatial regions to better model the tagging and size data; • Inclusion of catch estimates from Vietnam and some Japanese coastal longline data previously not included; • The use of operational longline data for multiple fleets to better address the contraction of the Japanese fleet and general changes over time in targeting practices; • Improved modelling of recruitment to ensure that uncertain estimates do not influence key stock status outcomes; and • A large amount of new tagging data corrected for differential post-release mortality and other tag losses	

Major Sources of Uncertainty	- Catch estimates from the most recent years are uncertain - Lack of availability of operational longline data for some fleets - High levels of uncertainty regarding the recruitment estimates and the resulting estimates of steepness

Qualifying Comments
-

Fishery Interactions
Interactions with protected species are known to occur in the longline fisheries of the South Pacific, particularly south of 25°S. Seabird bycatch mitigation measures are required in the New Zealand and Australian EEZs and through the WCPFC Conservation and Management Measure CMM2007-04. Sea turtles also get incidentally captured in longline gear; the WCPFC is attempting to reduce sea turtle interactions through Conservation and Management Measure CMM2008-03. Shark bycatch is common in longline fisheries and largely unavoidable; this is being managed through New Zealand domestic legislation and to a limited extent through Conservation and Management Measure CMM2010-07.

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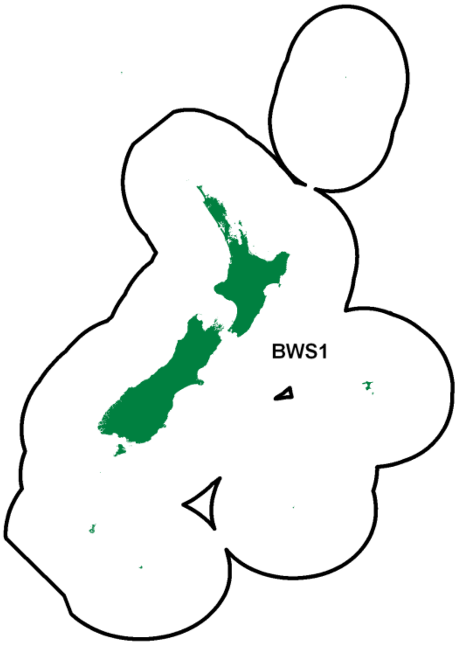
BLUE SHARK (BWS)

(*Prionace glauca*)



1. FISHERY SUMMARY

Blue shark was introduced into the QMS on 1 October 2004 under a single QMA, BWS 1, with allowances, TACC, and TAC in Table 1.

Table 1: Recreational and Customary non-commercial allowances, other mortalities, TACC and TAC (all in tonnes) for blue shark.

Fishstock	Recreational Allowance	Customary non-commercial Allowance	Other mortality	TACC	TAC
BWS 1	20	10	190	1 860	2 080

Blue shark was added to the Third Schedule of the 1996 Fisheries Act with a TAC set under s14 because blue shark is a highly migratory species and it is not possible to estimate MSY for the part of the stock that is found within New Zealand fisheries waters.

Blue shark was also added to the Sixth Schedule of the 1996 Fisheries Act with the provision that:

> "A commercial fisher may return any blue shark to the waters from which it was taken from if –
> (a) that blue shark is likely to survive on return; and
> (b) the return takes place as soon as practicable after the blue shark is taken."

Management of blue sharks throughout the western and central Pacific Ocean (WCPO) is the responsibility of the Western and Central Pacific Fisheries Commission (WCPFC). Under this regional convention New Zealand is responsible for ensuring that the management measures applied within New Zealand fisheries waters are compatible with those of the Commission.

1.1 Commercial fisheries

Most of the blue shark catch in the New Zealand EEZ is caught in the tuna surface longline fishery. Relatively little blue shark is caught by other methods. Data collected by the Ministry for

Primary Industries (MPI) Fishery Observer Services (formerly Ministry of Fisheries Observer Programme) from the tuna longline fishery suggest that most of the blue shark catch has been processed (72% of the observed catch), although prior to 1 October 2014 usually only the fins were retained and the rest of the carcass was dumped (over 99% of the processed, observed catch). Greenweight (total weight) was obtained by applying species specific conversion factors to the weight of the fins landed. On 1 October 2014 a ban on shark finning was introduced; after this time any blue sharks for which the fins are retained are required to be landed with the fins attached (artificial attachment such as tying or securing the fins to the trunk is permitted). Figure 1 shows historical landings and fishing effort for BWS 1 and BWS ET.

Landings of blue sharks reported by fishers on CELRs, Catch CLRs, or TLCERs and by processors on LFRRs and MHRs are given in Table 2. Total weights reported by fishers were 551–1167 t per annum during 1997–98 to 2007–08. Processors (LFRRs) reported 525–1415 t per annum during 1997-98 to 2012-13.

In addition to catches within New Zealand fisheries waters, small catches are taken by New Zealand vessels operating on the high seas (Figure 1).

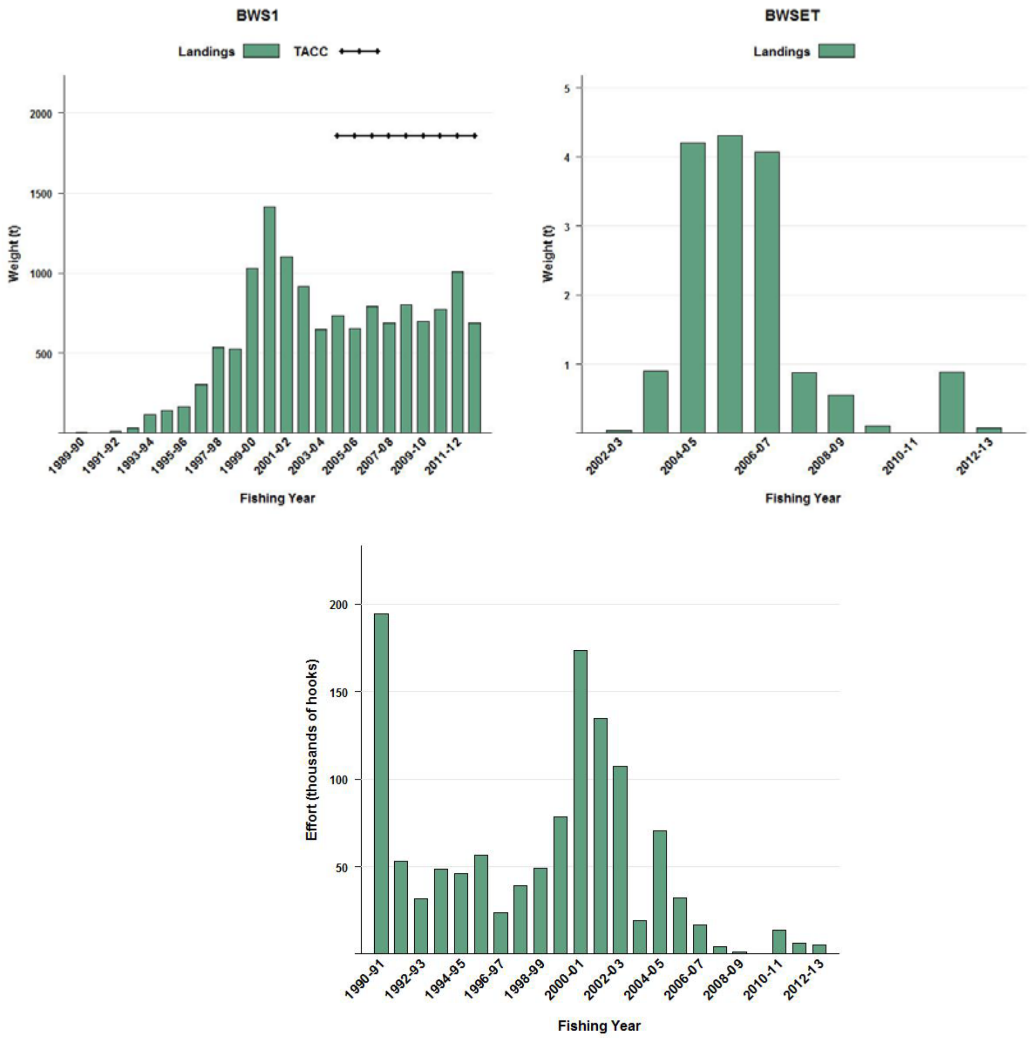


Figure 1: [Top] Blue Shark catch from 1989–90 to 2012–13 within New Zealand waters (BWS 1), and 2002–03 to 2012–13 on the high seas (BWS ET). [Bottom] Fishing effort (number of hooks set) for high seas New Zealand flagged surface longline vessels, from 1990–91 to 2012–13. [Figure continued on next page].

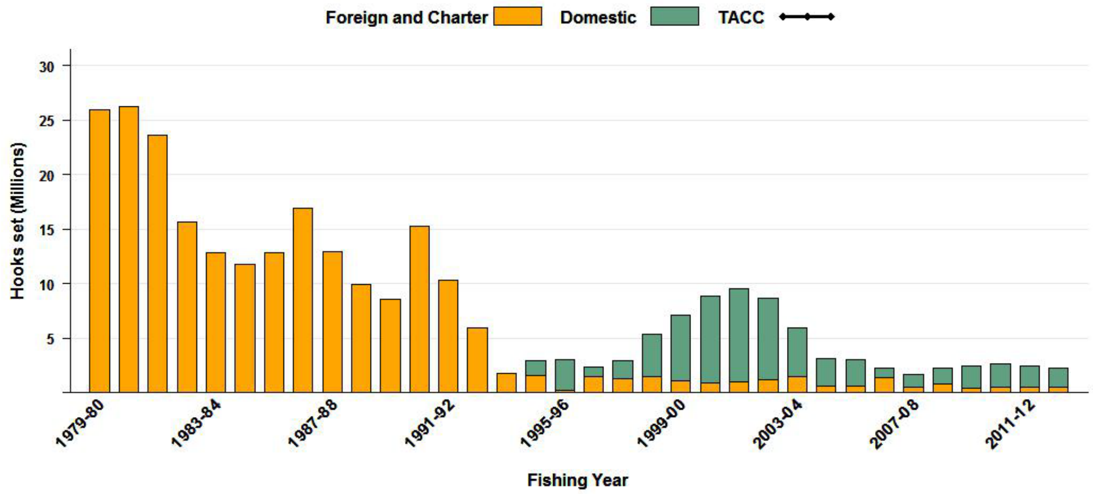


Figure 1 [Continued]: Fishing effort (number of hooks set) for all domestic and foreign vessels (including effort by foreign vessels chartered by New Zealand fishing companies), from 1988–89 to 2012–13

The majority of blue sharks (57%) are caught in the bigeye tuna fishery (Figure 2); although there are no directed blue shark fisheries, blue sharks form one of the three top catches by weight across all longline fisheries (17%) (Figure 3). Longline fishing effort is distributed along the east coast of the North Island and the south west coast of the South Island. The west coast South Island fishery predominantly targets southern bluefin tuna, whereas the east coast of the North Island targets a range of species including bigeye, swordfish, and southern bluefin tuna (Figure 4).

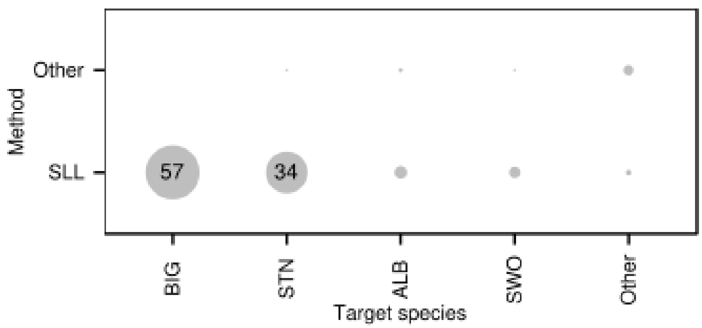


Figure 2: A summary of the proportion of landings of blue shark taken by each target fishery and fishing method. The area of each circle is proportional to the percentage of landings taken using each combination of fishing method and target species. The number in the circle is the percentage. SLL = surface longline (Bentley et al 2013).

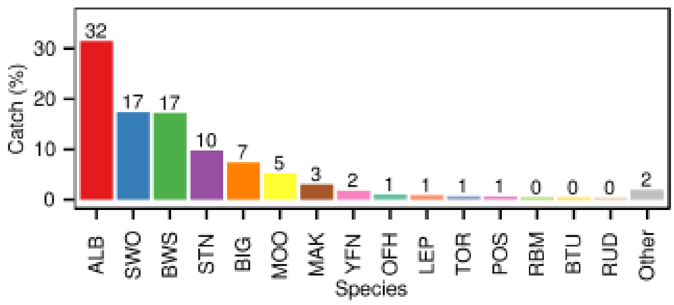


Figure 3: A summary of species composition of the reported surface longline catch. The percentage by weight of each species is calculated for all surface longline trips (Bentley et al 2013).

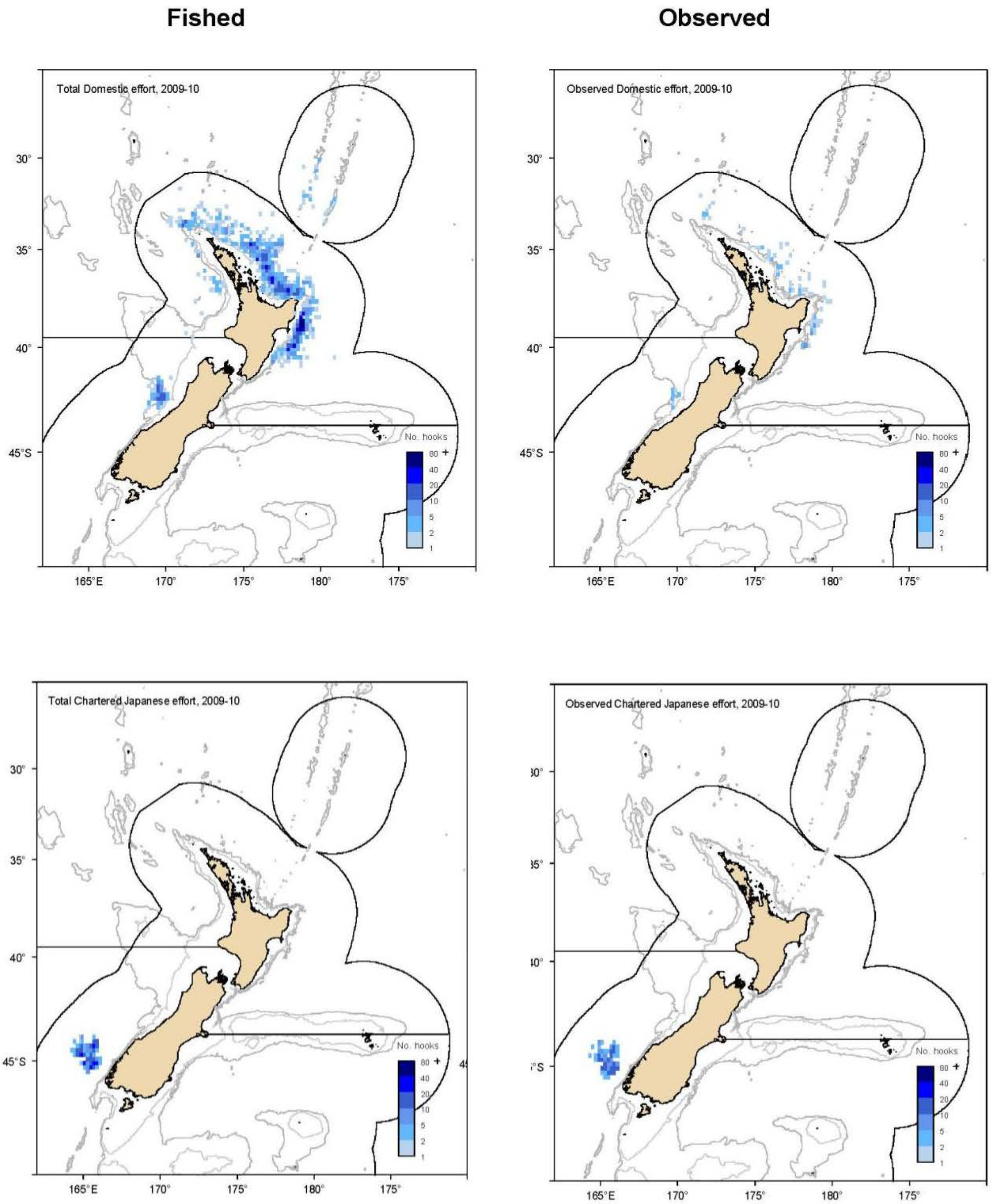


Figure 4: Distribution of fishing positions for domestic (top two panels) and charter (bottom two panels) vessels, for the 2009–10 fishing year, displaying both fishing effort (left) and observed effort (right).

Table 2: New Zealand estimated commercial landings of blue shark (t) reported by fishers on CELRs CLRs, or TLCERs and processors (LFRRs or MHRs) by fishing year.

Year	Total reported	LFRR/MHR
1989–90	12	5
1990–91	2	3
1991–92	18	13
1992–93	39	33
1993–94	371	118
1994–95	254	140
1995–96	152	166
1996–97	161	303
1997–98	551	537
1998–99	576	525
1999–00	641	1 031
2000–01	1 167	1 415
2001–02	1 076	1 105
2002–03*	968	914
2003–04*	649	649
2004–05*	734	734
2005–06*	656	656
2006–07*	790	794
2007–08*	681	687
2008–09*		804
2009–10*		696
2010–11*		770
2011–12*		1 011
2012–13*		691

[1] Note that there may be some misreporting of blue shark catches (MPI species code “BWS”) as bluenose (*Hyperoglyphe antarctica*; MPI species code “BNS”) and vice versa. *MHR rather than LFRR data.

Table 3: Percentage of blue shark (including discards) that were alive or dead when arriving at the longline vessel and observed during 2006–07 to 2012–13, by fishing year, fleet and region. Small sample sizes (number observed < 20) were omitted Griggs & Baird (2013). [Continued on next page]

Year	Fleet	Area	% alive	% dead	Number
2006–07	Australia	North	95.4	4.6	131
	Charter	North	89.8	10.2	2 155
		South	93.4	6.6	5 025
	Domestic	North	87.9	12.1	3 991
	Total		**90.8**	**9.2**	**11 302**
2007–08	Charter	South	89.2	10.8	2 560
	Domestic	North	88.6	11.4	5 599
	Total		**88.8**	**11.2**	**8 159**
2008–09	Charter	North	94.5	5.5	1 317
		South	95.1	4.9	4 313
	Domestic	North	92.0	8.0	3 935
		South	94.9	5.1	98
	Total		**93.7**	**6.3**	**9 663**
2009–10	Charter	South	95.6	4.4	2 004
	Domestic	North	85.7	14.3	2 853
		South	94.0	6.0	882
	Total		**90.5**	**9.5**	**5 739**
2010-11	Charter	North	100.0	0.0	25
		South	95.9	4.1	2 650
	Domestic	North	92.8	7.2	3 553
		South			0
	Total		**94.1**	**5.9**	**6 228**

Table 3 [Continued]:

2011-12	Charter	North	100.0	0.0	10
		South	93.0	7.0	5 394
	Domestic	North	93.5	6.5	5 672
		South	93.2	6.8	1 592
	Total		**93.2**	**6.8**	**12 668**
2012-13	Charter	North	96.1	3.9	256
		South	89.3	10.7	5 087
	Domestic	North	95.5	4.5	5 150
		South	95.6	4.4	180
	Total		**92.5**	**7.5**	**10 673**
Total all strata			**91.9**	**8.1**	**64 432**

Across all fleets in the longline fishery most of the blue sharks were alive (93%) when brought to the side of the vessel during 2010–11 to 2012–13 (Table 3). The foreign charter fleet retained most of the blue sharks (77–89%) mostly for fins, while practices within the domestic fleet were more variable, ranging from 12−53% of their blue shark catch retained, mostly for the fins. The domestic fleet retained some blue shark flesh in 2010–11 and 2011–12, and the percentage of blue sharks discarded by domestic vessels increased over the three year period (Table 4).

Table 4: Percentage of blue shark that were retained, or discarded or lost, when observed on a longline vessel during 2006–07 to 2012–13, by fishing year and fleet. Small sample sizes (number observed < 20) omitted Griggs & Baird (2013). [Continued on next page]

Year	Fleet	Area	% retained or finned	% discarded or lost	Number
2006–07	Australia		3.0	97.0	132
	Charter		85.1	14.9	8 272
	Domestic		33.2	66.8	3 994
	Total		**67.5**	**32.5**	**12 398**
2007–08	Charter		91.8	8.2	2 638
	Domestic		59.5	40.5	5 650
	Total		**69.8**	**30.2**	**8 288**
2008–09	Charter		87.5	12.5	5 723
	Domestic		54.0	46.0	4 049
	Total		**73.6**	**26.4**	**9 772**
2009–10	Charter		91.7	8.3	2 023
	Domestic		37.6	62.4	5 531
	Total		**52.1**	**47.9**	**7 554**
2010-11	Charter	North	100.0	0.0	25
		South	88.9	11.1	2 650
	Domestic	North	43.0	57.0	3 736
		South			0
	Total		**62.2**	**37.8**	**6 411**

Table 4 [Continued]:

2011-12	Charter	North	60.0	40.0	10
		South	86.2	13.8	5 394
	Domestic	North	44.2	55.8	6 346
		South	88.0	12.0	1 601
	Total		**66.4**	**33.6**	**13 351**
2012-13	Charter	North	72.7	27.3	256
		South	77.0	23.0	5 088
	Domestic	North	12.3	87.7	5 372
		South	0.0	100.0	180
	Total		**43.8**	**56.2**	**10 896**
Total all strata			**62.2**	**37.8**	**68 670**

Catches of blue sharks aboard tuna longline vessels are concentrated off the west and south-west coasts of the South Island, and the north-east coast of the North Island (Figure 5). Most of the blue shark landings reported by fishers (TLCERs) are concentrated in FMAs 1, 2 and 7.

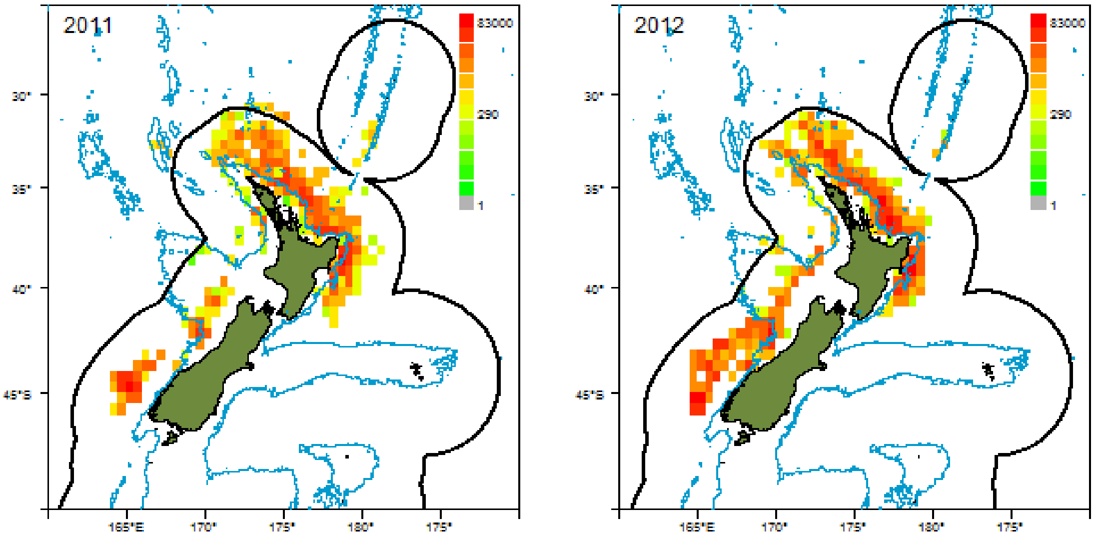


Figure 5: Blue shark catches (kg) by the surface longline fishery in 0.5 degree rectangles by fishing year. Note the log scale used for the colour palette. Depth contour = 1000 m. Source: TLCER data (Francis et al. 2014) [Continued on next page].

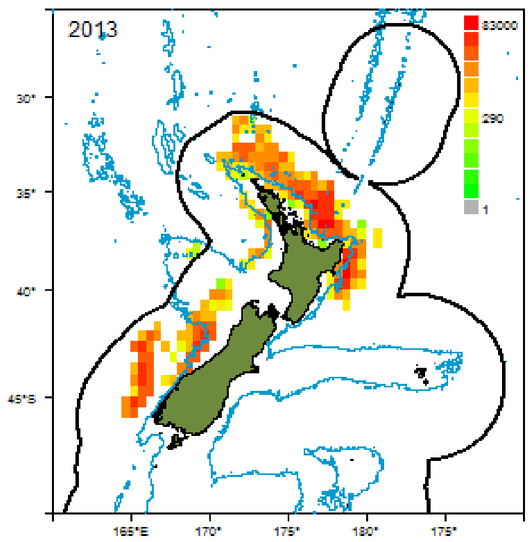


Figure 5 [Continued]: Blue shark catches (kg) by the surface longline fishery in 0.5 degree rectangles by fishing year. Note the log scale used for the colour palette. Depth contour = 1000 m. Source: TLCER data (Francis et al. 2014).

1.2 Recreational fisheries

Blue sharks are caught in relatively large numbers by recreational fishers in the New Zealand EEZ. Although not as highly regarded as other large, pelagic sharks such as mako in northern New Zealand, blue sharks are the primary target gamefish in southern New Zealand. Several hundred blue sharks were tagged and released each year by recreational fishers off Otago Heads in the late 1990s as part of the New Zealand Gamefish Tagging Programme,. About 100 blue sharks have been tagged per year for the last ten years. The total recreational catch is unknown but most are released.

1.3 Customary non-commercial fisheries

Prior to European settlement, Maori caught large numbers of cartilaginous fishes, including blue sharks. However, there are no estimates of current Maori customary catch.

1.4 Illegal catch

There is no known illegal catch of blue sharks.

1.5 Other sources of mortality

About 91% of all observed blue sharks caught in the tuna longline fishery are retrieved alive. About 33% of all observed blue sharks are discarded. The proportion of sharks discarded dead is unknown. Mortality rates of blue sharks tagged and released by the New Zealand Gamefish Tagging Programme are also unknown.

2. BIOLOGY

Blue sharks (*Prionace glauca*) are large, highly migratory, pelagic carcharhinids found throughout the world's oceans in all tropical and temperate waters from about 50° N to 50° S. They are slender in build, rarely exceeding 3 m in total length and 200 kg in weight. They feed opportunistically on a range of living and dead prey, including bony fishes, smaller sharks, squid and carrion.

In New Zealand waters, male blue sharks are sexually mature at about 190–195 cm fork length (FL) and females at about 170–190 cm FL. Gestation in female blue sharks lasts between 9–12 months and between 4–135 pups (averaging 26–56) are born alive, probably during the spring.

Pups are probably born at about 50 cm FL. The few embryos from New Zealand fisheries waters examined to date consisted of mid-term pups 21–37 cm FL collected in July and a full-term pup 54 cm FL collected in February. Blue sharks 50–70 cm FL are caught year-round in New Zealand fisheries waters but only in small numbers.

Age and growth estimates are available for blue sharks in New Zealand waters. These estimates were derived from counts of opaque growth zones in X-radiographs of sectioned vertebrae with the assumption that one opaque zone is formed per year. This assumption is untested. Female blue sharks appear to approach a lower mean asymptotic maximum length and grow at a faster rate than males. This differs from the age and growth analyses of blue shark from other oceans, where females typically approach a larger mean asymptotic maximum length than males. This is thought to result from the presence of relatively few large (over 250 cm FL), old female blue sharks in the length-at-age dataset analysed.

Table 5: Estimates of biological parameters.

Fishstock	Estimate					Source
1. Natural mortality (M)						
BWS 1	0.19–0.21					Manning & Francis (2005)
2. Weight = a (length)^{b} (Weight in kg, length in cm fork length)						
		a	b			
BWS 1 males		1.578×10^{-6}	3.282			Ayers et al (2004)
BWS 1 females		6.368×10^{-7}	3.485			
3. Von Bertalanffy model parameter estimates						
	k	t_0	L_∞			
BWS 1 males	0.0668	-1.7185	390.92			Manning & Francis (2005)
BWS 1 females	0.1106	-1.2427	282.76			
4. Schnute model (case 1) parameter estimates (are provided for comparison with the von Bertalanffy estimates above)						
	L_1	L_2	κ	γ	L_∞	
BWS 1 males	65.21	217.48	0.1650	0.1632	297.18	Manning & Francis (2005)
BWS 1 females	63.50	200.60	0.2297	0.0775	235.05	

The MPI observer data suggest that large (over 250 cm FL) female blue sharks are missing from the catch, despite reliable personal observations to the contrary from commercial and recreational fishers. There is evidence of size and sex segregation in the distributions of blue sharks in the North Pacific, with large, pregnant females tending to be found nearer the equator than males or smaller females. It is possible that large female blue sharks occur in New Zealand but have not been adequately sampled by observers.

Growth rates estimated for New Zealand blue sharks are broadly comparable with overseas studies. Males and females appear to grow at similar rates until about seven years of age, when their growth appears to diverge. Age-at-maturity is estimated at 8 years for males and 7–9 years for females. The maximum recorded ages of male and female blue sharks in New Zealand waters are 22 and 19 years, respectively. Blue sharks appear to be fully recruited to the commercial longline fishery by the end of their second year. The commercial catch sampled by MPI observers consists of both immature and mature fish.

Estimates of biological parameters for blue sharks in New Zealand waters are given in Table 5.

3. STOCKS AND AREAS

The New Zealand Gamefish Tagging Programme has tagged and released 4674 blue sharks between 1979–80 and 2013–14 in the New Zealand EEZ. Most tagged sharks were captured and released off the east coast of the South Island. A total of 87 tagged sharks have been recaptured since the start of the tagging programme. The recapture data show dispersal of tagged sharks away from their release point, although the relationship between time at liberty and dispersal is unclear. While some tagged sharks have been recaptured with little apparent net movement away from their release point, others have been recaptured off from Australia, New Caledonia, Vanuatu, Fiji, Tonga, Cook Islands and French Polynesia (Figure 6). The longest movement recorded from a blue shark released in New Zealand was from a fish recaptured off Chile.

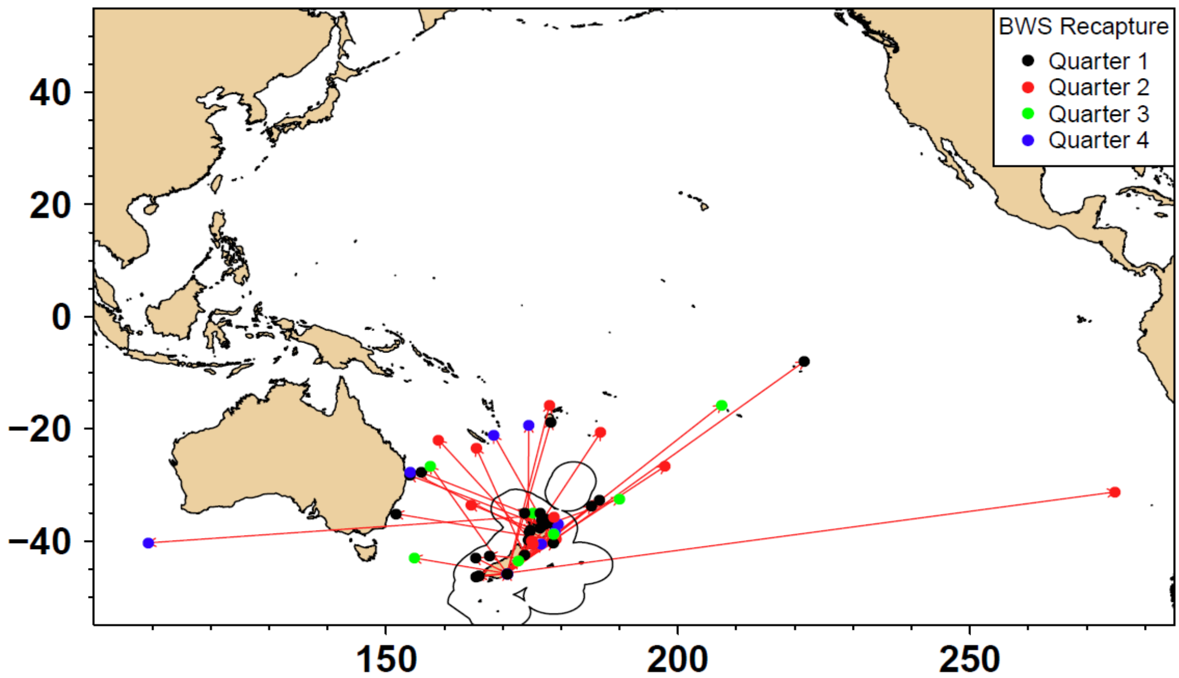


Figure 6: All release and recapture locations of blue sharks in the gamefish tagging programme, 1982–2012.

Although the data are relatively sparse, an overview of tagging data from Australia, New Zealand, the Central Pacific and California suggests population exchange exists between not only the eastern and western South Pacific, but also between the South Pacific, south Indian, and even South Atlantic oceans. This suggests that blue sharks in the South Pacific constitute a single biological stock, although whether this is part of a single larger Southern Hemisphere stock is unclear.

No other data are available on blue shark stock structure in the South Pacific.

4. ENVIRONMENTAL AND ECOSYSTEM CONSIDERATIONS

This section was updated for the November 2014 Fishery Assessment Plenary after review by the Aquatic Environment Working Group. This summary is from the perspective of blue shark but there is no directed fishery for them and the incidental catch sections below reflect the New Zealand longline fishery as a whole and are not specific to this species; a more detailed summary from an issue-by-issue perspective is available in the Aquatic Environment and Biodiversity Annual Review where the consequences are also discussed. (http://www.mpi.govt.nz/Default.aspx?TabId=126&id=2122) (Ministry for Primary Industries (2013a).

4.1 Role in the ecosystem

Blue shark (*Prionace glauca*) are active pelagic predators of bony fishes and squid. Small blue sharks (less than 1 m) feed predominantly on squid but switch to a diet dominated by fish as they grow (Figure 7) (Griggs et al 2007).

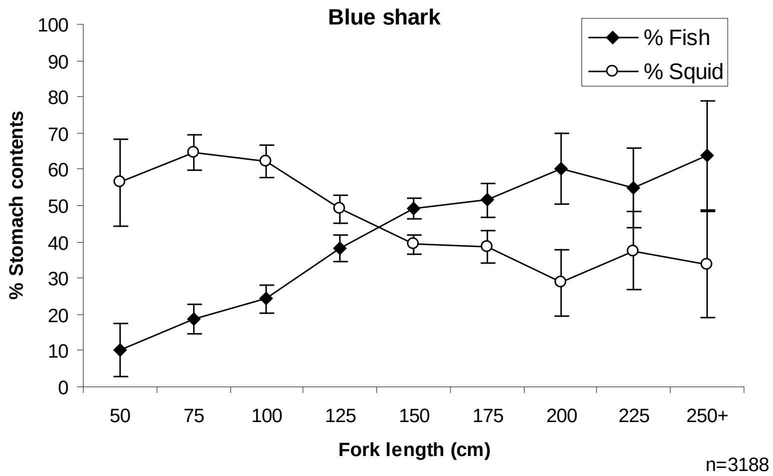


Figure 7: Change in percentage of fish and squid in stomachs of blue shark as a function of fork length.

4.2 Incidental catch (seabirds, sea turtles and mammals)

The protected species capture estimates presented here include all animals recovered onto the deck (alive, injured or dead) of fishing vessels but do not include any cryptic mortality (e.g., seabirds caught on a hook but not brought onboard the vessel).

4.2.1 Seabird bycatch

Between 2002–03 and 2012–13, there were 818 observed captures of birds across other surface longline target fisheries (those not targeting albacore tuna, bigeye tuna, southern bluefin tuna, pacific bluefin tuna and swordfish). Seabird capture rates since 2003 are presented in Table 5 and Figures 8 and 9. Peaks in seabird capture rates occurred in 2006-07 and 2008-09. Seabird captures were more frequent off the south west coast of the South Island (Figure 10). Bayesian models of varying complexity dependent on data quality have been used to estimate captures across a range of methods (Richard & Abraham 2014). Observed and estimated seabird captures in albacore longline fisheries are provided in Table 6.

Through the 1990s the minimum seabird mitigation requirement for surface longline vessels was the use of a bird scaring device (tori line) but common practice was that vessels set surface longlines primarily at night. In 2007 a notice was implemented under s 11 of the Fisheries Act 1996 to formalise the requirement that surface longline vessels only set during the hours of darkness and use a tori line when setting. This notice was amended in 2008 to add the option of line weighting and tori line use if setting during the day. In 2011 the notices were combined and repromulgated under a new regulation (Regulation 58A of the Fisheries (Commercial Fishing) Regulations 2001) which provides a more flexible regulatory environment under which to set seabird mitigation requirements.

Risk posed by commercial fishing to seabirds has been assessed via a level 2 method which supports much of the NPOA-Seabirds 2013 risk assessment framework (MPI 2013b). The method used in the level 2 risk assessment arose initially from an expert workshop hosted by the Ministry of Fisheries in 2008. The overall framework is described in Sharp et al. (2011) and has been variously applied and improved in multiple iterations (Waugh et al. 2009, Richard et al. 2011, Richard and Abraham 2013, Richard et al. 2013 and Richard & Abraham in press). The method applies an “exposure-effects” approach where exposure refers to the number of fatalities is calculated from the overlap of seabirds with fishing effort compared with observed captures to estimate the species vulnerability (capture rates per encounter) to each fishery group. This is then compared to the population’s productivity, based on population estimates and biological characteristics to yield estimates of population-level risk.

The 2014 iteration of the seabird risk assessment (Richard & Abraham in press) assessed other surface longline target fisheries (those not targeting albacore tuna, bigeye tuna, southern bluefin tuna, pacific bluefin tuna and swordfish) contribution to the total risk posed by New Zealand commercial fishing to seabirds (see Table 12). These target fisheries contribute 0.003 of PBR_1 to the risk to Southern Buller's albatross which was assessed to be at very high risk from New Zealand commercial fishing (Richard & Abraham in press).

Table 5: Number of observed seabird captures in the New Zealand surface longline fisheries, 2002–03 to 2012–13, by species and area. See glossary above for a description of the areas used for summarising the fishing effort and protected species captures. The risk ratio is an estimate of aggregate potential fatalities across trawl and longline fisheries relative to the Potential Biological Removals, PBR (from Richard and Abraham (2013) where full details of the risk assessment approach can be found). It is not an estimate of the risk posed by fishing for blue shark using longline gear but rather the total risk for each seabird species. Other data, version 20130305.

Albatross Species	Risk Ratio	Kermadec Islands	Northland and Hauraki	Bay of Plenty	East Coast North Island	Stewart Snares Shelf	Fiordland	West Coast South Island	West Coast North Island	Total
Salvin's	Very high	0	1	2	6	0	0	0	0	9
Southern Buller's	Very high	0	5	2	27	0	280	39	0	353
NZ white-capped	Very high	0	2	0	3	10	62	36	1	114
Northern Buller's	High	0	0	0	1	0	0	0	0	1
Gibson's	High	4	16	0	17	0	6	3	1	47
Antipodean	High	12	10	1	8	0	0	0	1	32
Northern royal	Medium	0	0	1	0	0	0	0	0	1
Southern royal	Medium	0	1	0	0	0	4	1	0	6
Campbell black-browed	Medium	2	10	2	29	0	3	3	1	50
Light-mantled sooty	Very low	0	0	0	0	0	0	1	0	1
Unidentified	N/A	38	2	0	2	0	0	0	1	43
Total	**N/A**	**56**	**47**	**8**	**93**	**10**	**355**	**83**	**5**	**657**
Other seabirds										
Black petrel	Very high	1	10	1	0	0	0	0	1	13
Flesh-footed shearwater	Very high	0	0	0	10	0	0	0	2	12
Cape petrel	High	0	0	0	2	0	0	0	0	2
Westland petrel	Medium	0	0	0	2	0	1	6	0	9
White-chinned petrel	Medium	2	3	3	3	1	20	3	3	38
Grey petrel	Medium	3	4	3	38	0	0	0	0	48
Grey-faced petrel	Very low	12	5	1	2	0	0	0	0	20
Sooty shearwater	Very low	1	0	0	8	3	1	0	0	13
Southern giant petrel	-	0	0	2	0	0	0	0	2	0
White-headed petrel	-	2	0	0	0	0	0	0	0	2
Unidentified	N/A	0	1	0	0	0	1	0	0	2
Total	**N/A**	**21**	**23**	**10**	**65**	**4**	**23**	**9**	**8**	**159**

Table 6: Effort, observed and estimated seabird captures by fishing year for the New Zealand surface longline fishery within the EEZ. For each fishing year, the table gives the total number of hooks; the number of observed hooks; observer coverage (the percentage of hooks that were observed); the number of observed captures; the capture rate (captures per thousand hooks); and the mean number of estimated total captures (with 95% confidence interval). Estimates are based on methods described in Thompson et al (2013) are available via http://www.fish.govt.nz/en-nz/Environmental/Seabirds/. Estimates from 2002–03 to 2010–11 and preliminary estimates for 2012–13 are based on data version 20140131.

	Fishing effort			Observed captures		Estimated captures	
Fishing year	All hooks	Observed hooks	% observed	Number	Rate	Mean	95% c.i.
2002–2003	10 772 188	2 195 152	20.4	115	0.052	2 088	1 613–2 807
2003–2004	7 386 329	1 607 304	21.8	71	0.044	1 395	1 086–1 851
2004–2005	3 679 765	783 812	21.3	41	0.052	617	483–793
2005–2006	3 690 119	705 945	19.1	37	0.052	808	611–1 132
2006–2007	3 739 912	1 040 948	27.8	187	0.18	958	736–1 345
2007–2008	2 246 189	421 900	18.8	37	0.088	524	417–676
2008–2009	3 115 633	937 496	30.1	57	0.061	609	493–766
2009–2010	2 995 264	665 883	22.2	135	0.203	939	749–1 216
2010–2011	3 187 879	674 572	21.2	47	0.07	705	532–964
2011–2012	3 100 277	728 190	23.5	64	0.088	829	617–1 161
2012–2013†	2 862 182	560 333	19.6	27	0.048	783	567–1 144

†Provisional data, model estimates not finalised.

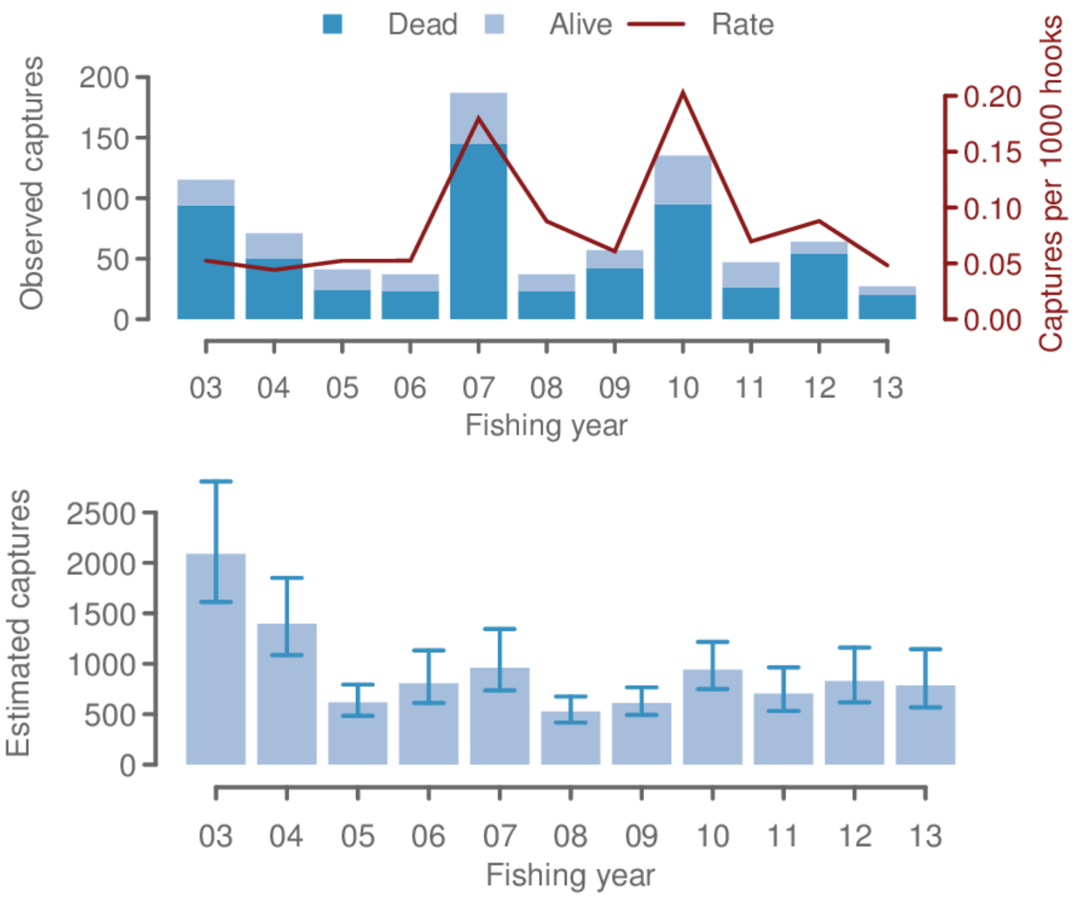


Figure 8: Observed and estimated captures of seabirds in the New Zealand surface longline fisheries from 2002–03 to 2012–13.

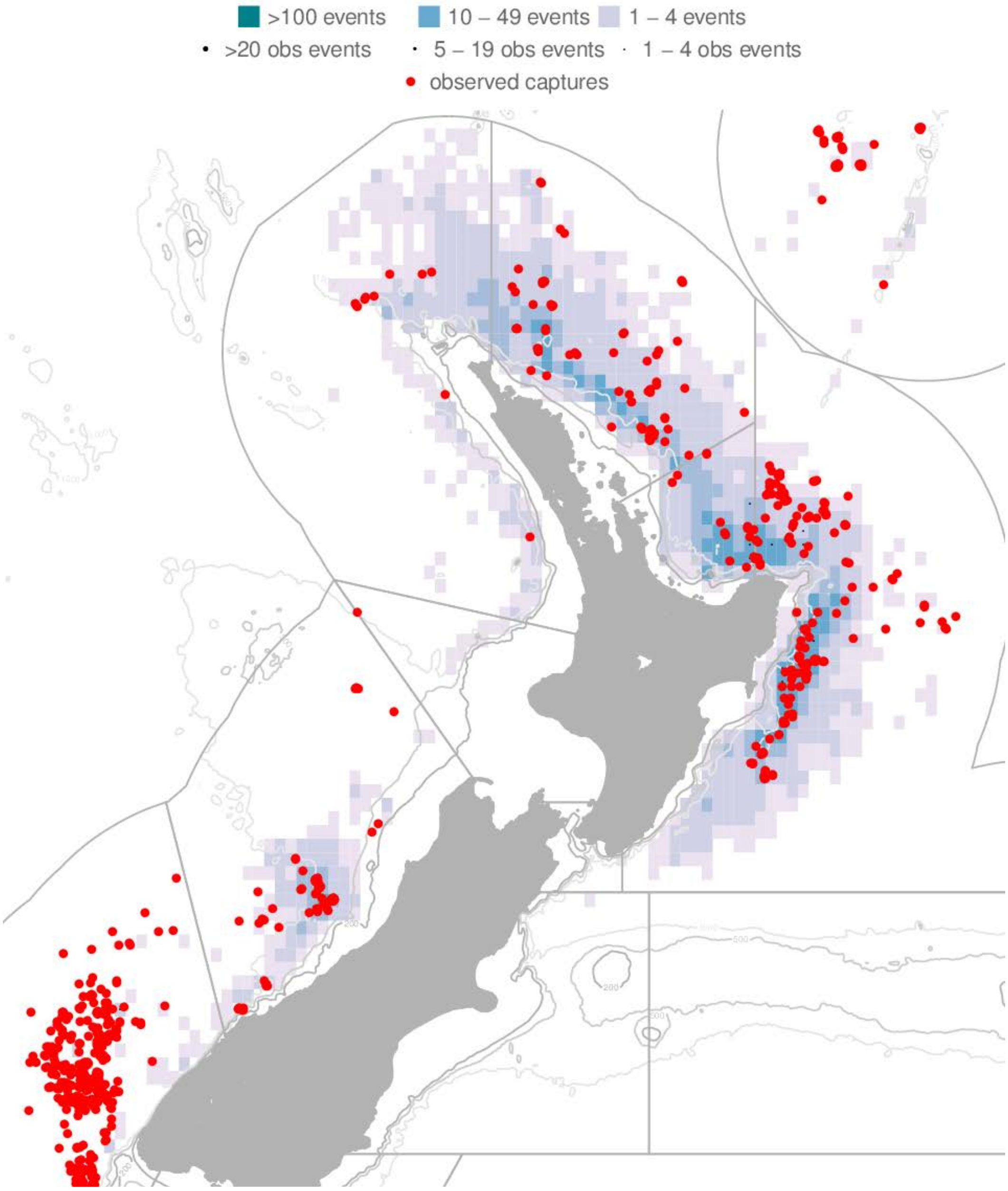


Figure 10: Distribution of fishing effort in the New Zealand surface longline fisheries and observed seabird captures, 2002–03 to 2012–13. Fishing effort is mapped into 0.2-degree cells, with the colour of each cell being related to the amount of effort. Observed fishing events are indicated by black dots, and observed captures are indicated by red dots. Fishing is only shown if the effort could be assigned a latitude and longitude, and if there were three or more vessels fishing within a cell. In this case, 94.1% of the effort is shown. See glossary for areas used for summarising the fishing effort and protected species captures.

Table 7: Risk ratio of seabirds predicted by the level two risk assessment for the other species target surface longline fisheries (those not targeting albacore tuna, bigeye tuna, southern bluefin tuna, pacific bluefin tuna and swordfish) and all fisheries included in the level two risk assessment, 2006–07 to 2012–13, showing seabird species with risk category of very or high, or a medium risk category and risk ratio of at least 1% of the total risk. The risk ratio is an estimate of aggregate potential fatalities across trawl and longline fisheries relative to the Potential Biological Removals, PBR_1 (from Richard and Abraham 2014 where full details of the risk assessment approach can be found). PBR_1 applies a recovery factor of 1.0. Typically a recovery factor of 0.1 to 0.5 is applied (based on the state of the population) to allow for recovery from low population sizes as quickly as possible. This should be considered when interpreting these results. The New Zealand threat classifications are shown (Robertson et al 2013 at http://www.doc.govt.nz/documents/science-and-technical/nztcs4entire.pdf)

	Risk ratio				
Species name	OTH target SLL	Total risk from NZ commercial fishing	% of total risk from NZ commercial fishing	Risk category	NZ Threat Classification
Black petrel	0.000	15.095	0.00	Very high	Threatened: Nationally Vulnerable
Salvin's albatross	0.000	3.543	0.00	Very high	Threatened: Nationally Critical
Southern Buller's albatross	0.003	2.823	0.10	Very high	At Risk: Naturally Uncommon
Flesh-footed shearwater	0.000	1.557	0.00	Very high	Threatened: Nationally Vulnerable
Gibson's albatross	0.000	1.245	0.00	Very high	Threatened: Nationally Critical
New Zealand white-capped albatross	0.000	1.096	0.01	Very high	At Risk: Declining
Chatham Island albatross	0.000	0.913	0.00	High	At Risk: Naturally Uncommon
Antipodean albatross	0.000	0.888	0.00	High	Threatened: Nationally Critical
Westland petrel	0.000	0.498	0.00	High	At Risk: Naturally Uncommon
Northern Buller's albatross	0.000	0.336	0.13	High	At Risk: Naturally Uncommon
Campbell black-browed albatross	0.000	0.304	0.00	High	At Risk: Naturally Uncommon
Stewart Island shag	0.000	0.301	0.00	High	Threatened: Nationally Vulnerable

4.2.2 Sea turtle bycatch

Between 2002–03 and 2012–13, there were 15 observed captures of sea turtles across all surface longline fisheries (Tables 8 and 9, Figure 11). Observer records documented all but one sea turtle as captured and released alive. Sea turtle capture distributions predominantly occur throughout the east coast of the North Island and Kermadec Island fisheries (Figure 12).

Table 8: Number of observed sea turtle captures in the New Zealand surface longline fisheries, 2002–03 to 2012–13, by species and area. Data from Thompson et al (2013), retrieved from http://data.dragonfly.co.nz/psc/. See glossary above for a description of the areas used for summarising the fishing effort and protected species captures.

Species	Bay of Plenty	East Coast North Island	Kermadec Islands	West Coast North Island	Total
Leatherback turtle	1	4	3	3	11
Green turtle	0	1	0	0	1
Unknown turtle	0	1	0	2	3
Total	1	6	3	5	15

Table 9: Effort and sea turtle captures in surface longline fisheries by fishing year. For each fishing year, the table gives the total number of hooks; the number of observed hooks; observer coverage (the percentage of hooks that were observed); the number of observed captures (both dead and alive); and the capture rate (captures per thousand hooks). For more information on the methods used to prepare the data see Thompson et al (2013).

	Fishing effort			Observed captures	
Fishing year	All hooks	Observed hooks	% observed	Number	Rate
2002–2003	10 772 188	2 195 152	20.4	0	0
2003–2004	7 386 329	1 607 304	21.8	1	0.001
2004–2005	3 679 765	783 812	21.3	2	0.003
2005–2006	3 690 119	705 945	19.1	1	0.001
2006–2007	3 739 912	1 040 948	27.8	2	0.002
2007–2008	2 246 189	421 900	18.8	1	0.002
2008–2009	3 115 633	937 496	30.1	2	0.002
2009–2010	2 995 264	665 883	22.2	0	0
2010–2011	3 187 879	674 572	21.2	4	0.006
2011–2012	3 100 277	728 190	23.5	0	0
2012–2013	2 862 182	560 333	19.6	2	0.004

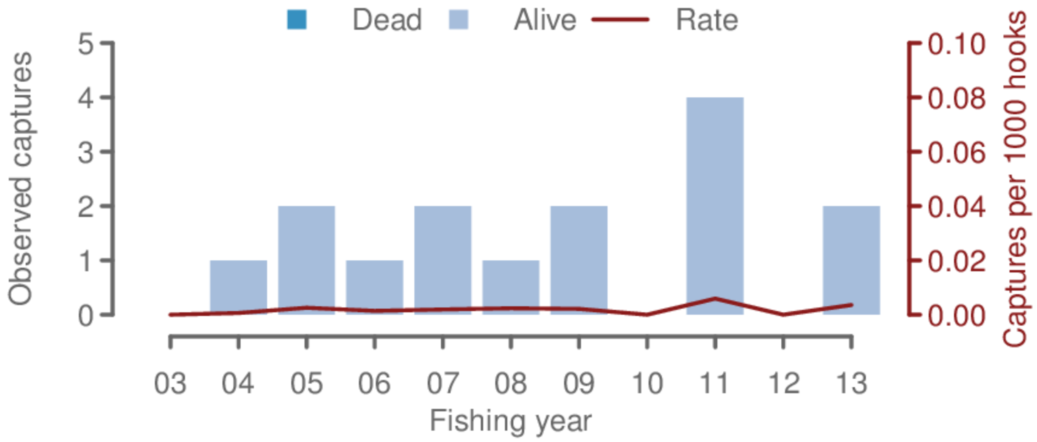
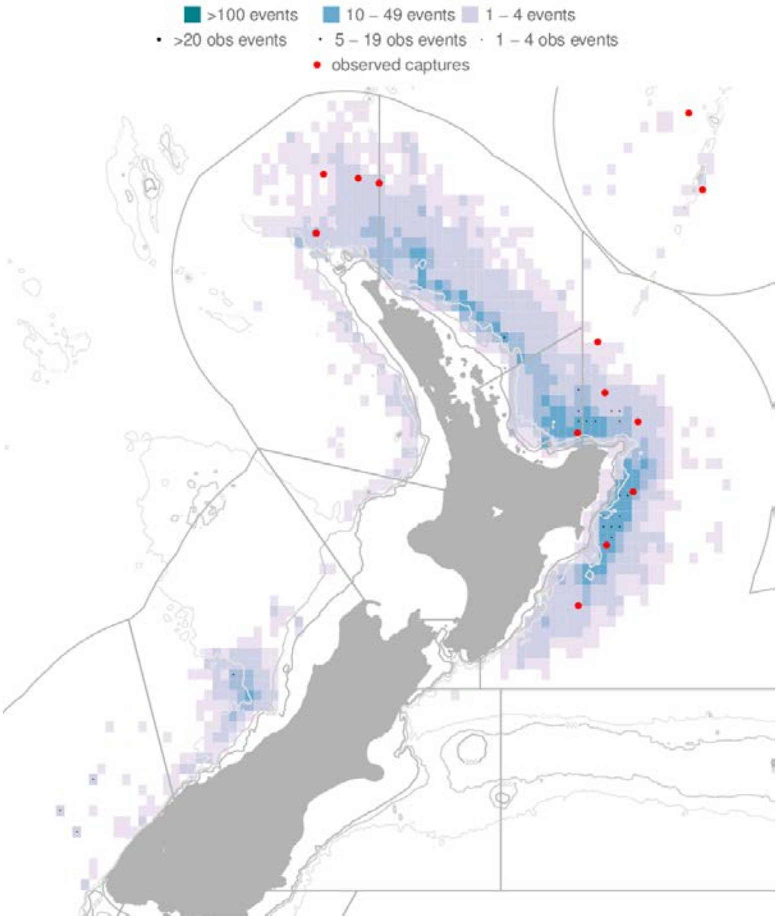


Figure 11: Observed captures of sea turtles in the New Zealand surface longline fisheries from 2002–03 to 2012–13.



312: Distribution of fishing effort in the New Zealand surface longline fisheries and observed sea turtle captures, 2002–03 to 2012–13. Fishing effort is mapped into 0.2-degree cells, with the colour of each cell being related to the amount of effort. Observed fishing events are indicated by black dots, and observed captures are indicated by red dots. Fishing is only shown if the effort could be assigned a latitude and longitude, and if there were three or more vessels fishing within a cell. In this case, 89.4% of the effort is shown. See glossary for areas used for summarising the fishing effort and protected species captures.

4.2.3 Marine Mammals

4.2.3.1 Cetaceans

Cetaceans are dispersed throughout New Zealand waters (Perrin et al 2008). The spatial and temporal overlap of commercial fishing grounds and cetacean foraging areas has resulted in cetacean captures in fishing gear (Abraham & Thompson 2009, 2011).

Between 2002–03 and 2012–13, there were seven observed captures of whales and dolphins in surface longline fisheries. Observed captures included 5 unidentified cetaceans and 2 long-finned Pilot whales (Tables 10 and 11, Figure 13) (Thompson et al 2013). All captured animals recorded were documented as being caught and released alive (Thompson et al. 2013). Cetacean capture distributions are more frequent off the east coast of the North Island (Figure 14)

Table 10: Number of observed cetacean captures in the New Zealand surface longline fisheries, 2002–03 to 2012–13, by species and area. Data from Thompson et al (2013), retrieved from http://data.dragonfly.co.nz/psc/. See glossary above for a description of the areas used for summarising the fishing effort and protected species captures.

Species	Bay of Plenty	East Coast North Island	Fiordland	Northland and Hauraki	West Coast North Island	West Coast South Island	Total
Long-finned pilot whale	0	1	0	0	0	1	2
Unidentified cetacean	1	1	1	1	1	0	5
Total	1	2	1	1	1	1	7

Table 11: Effort and captures of cetaceans in surface longline fisheries by fishing year. For each fishing year, the table gives the total number of hooks; the number of observed hooks; observer coverage (the percentage of hooks that were observed); the number of observed captures (both dead and alive); and the capture rate (captures per thousand hooks). For more information on the methods used to prepare the data, see Thompson et al (2013).

	Fishing effort			Observed captures	
Fishing year	All hooks	Observed hooks	% observed	Number	Rate
2002–2003	10 772 188	2 195 152	20.4	1	0
2003–2004	7 386 329	1 607 304	21.8	4	0.002
2004–2005	3 679 765	783 812	21.3	1	0.001
2005–2006	3 690 119	705 945	19.1	0	0
2006–2007	3 739 912	1 040 948	27.8	0	0
2007–2008	2 246 189	421 900	18.8	1	0.002
2008–2009	3 115 633	937 496	30.1	0	0
2009–2010	2 995 264	665 883	22.2	0	0
2010–2011	3 187 879	674 572	21.2	0	0
2011–2012	3 100 277	728 190	23.5	0	0
2012–13	2 862 182	560 333	19.6	0	0

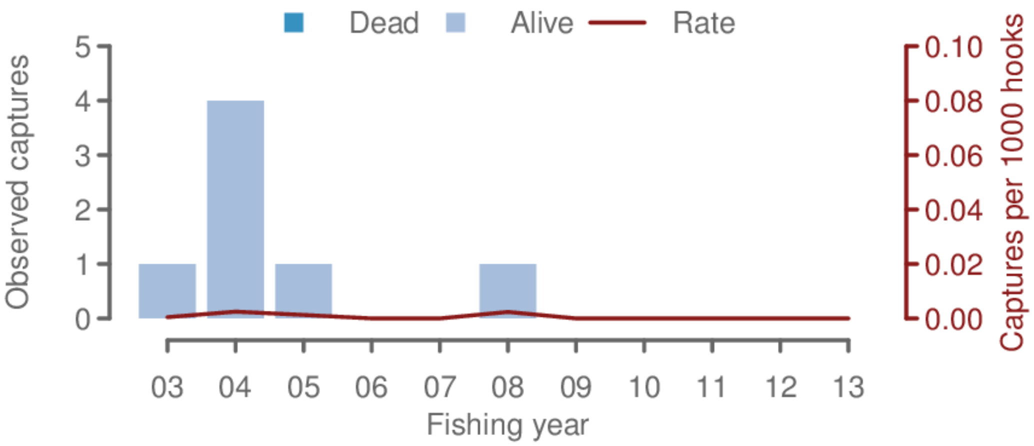


Figure 13: Observed captures of cetaceans in the New Zealand surface longline fisheries from 2002–03 to 2012–13.

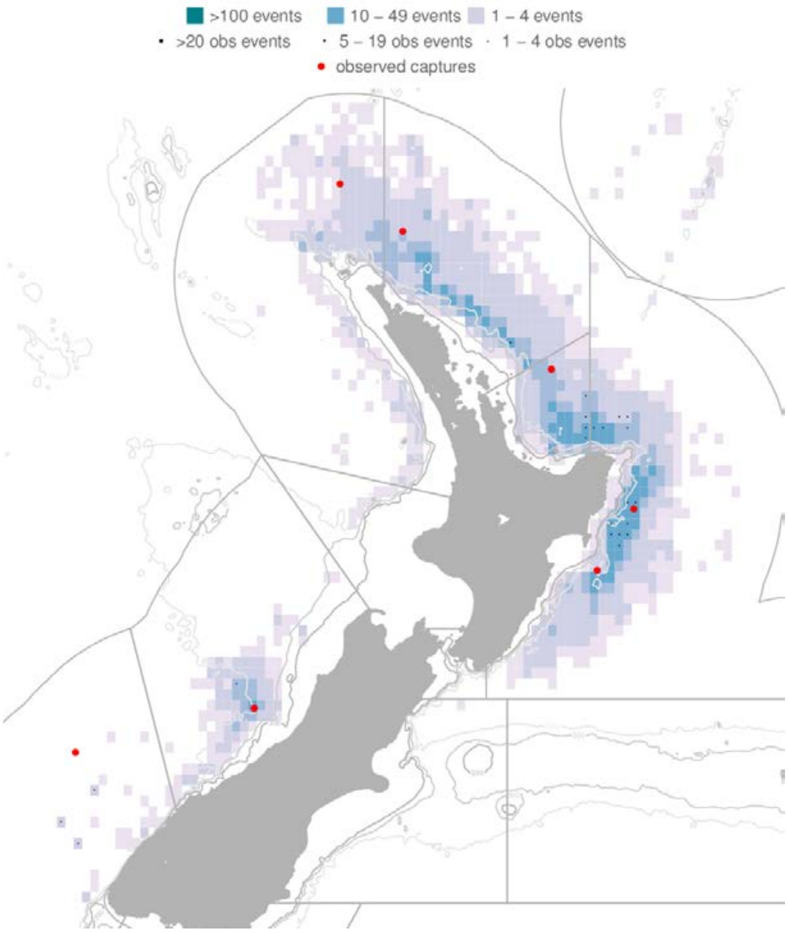


Figure 14: Distribution of fishing effort in the New Zealand surface longline fisheries and observed cetacean captures, 2002–03 to 2012–13. Fishing effort is mapped into 0.2-degree cells, with the colour of each cell being related to the amount of effort. Observed fishing events are indicated by black dots, and observed captures are indicated by red dots. Fishing is only shown if the effort could be assigned a latitude and longitude, and if there were three or more vessels fishing within a cell. In this case, 84.9% of the effort is shown. See glossary for areas used for summarising the fishing effort and protected species captures.

4.2.3.2 New Zealand fur seal bycatch

Currently, New Zealand fur seals are dispersed throughout New Zealand waters, especially in waters south of about 40º S to Macquarie Island. The spatial and temporal overlap of commercial fishing grounds and New Zealand fur seal foraging areas has resulted in New Zealand fur seal captures in fishing gear (Mattlin 1987, Rowe 2009). Most fisheries with observed captures occur in waters over or close to the continental shelf, which slopes steeply to deeper waters relatively close to shore, and thus rookeries and haulouts, around much of the South Island and offshore islands. Captures on longlines occur when the fur seals attempt to feed on the bait and fish catch during hauling. Most New Zealand fur seals are released alive, typically with a hook and short snood or trace still attached.

New Zealand fur seal captures in surface longline fisheries have been generally observed in waters south and west of Fiordland, but also in the Bay of Plenty-East Cape area when the animals have attempted to take bait or fish from the line as it is hauled. These capture rates include animals that are released alive (100% of observed surface longline capture in 2008–09; Thompson & Abraham 2010). Capture rates in 2011–12 and 2012-13 were higher than they were in the early 2000s (Figures 15 and 16). While fur seal captures have occurred throughout the range of this fishery most New Zealand captures have occurred off the Southwest coast of the

South Island (Figure 17). Between 2002–03 and 2012–13, there were 267 observed captures of New Zealand fur seal in surface longline fisheries (Tables 12 and 13).

Table 12: Number of observed New Zealand fur seal captures in the New Zealand surface longline fisheries, 2002–03 to 2012–13, by species and area. Data from Thompson et al (2013), retrieved from http://data.dragonfly.co.nz/psc/. See glossary above for a description of the areas used for summarising the fishing effort and protected species captures.

	Bay of Plenty	East Coast North Island	Fiordland	Northland and Hauraki	Stewart Snares Shelf	West Coast North Island	West Coast South Island	Total
New Zealand fur seal	11	33	179	4	4	2	34	267

Table 13: Effort and captures of New Zealand fur seal in the New Zealand surface longline fisheries by fishing year. For each fishing year, the table gives the total number of hooks; the number of observed hooks; observer coverage (the percentage of hooks that were observed); the number of observed captures (both dead and alive); and the capture rate (captures per thousand hooks). Data from Thompson et al (2013), retrieved from http://data.dragonfly.co.nz/psc/. Estimates from 2002–03 to 2010–11 and preliminary estimates for 2012–13 are based on data version 20140131.

	Fishing effort			Observed captures		Estimated captures	
Fishing year	All hooks	Observed hooks	% observed	Number	Rate	Mean	95% c.i.
2002–2003	10 772 188	2 195 152	20.4	56	0.026	299	199–428
2003–2004	7 386 329	1 607 304	21.8	40	0.025	134	90–188
2004–2005	3 679 765	783 812	21.3	20	0.026	66	38–99
2005–2006	3 690 119	705 945	19.1	12	0.017	47	23–79
2006–2007	3 739 912	1 040 948	27.8	10	0.010	32	14–55
2007–2008	2 246 189	421 900	18.8	10	0.024	40	19–68
2008–2009	3 115 633	937 496	30.1	22	0.023	53	29–81
2009–2010	2 995 264	665 883	22.2	19	0.029	77	43–121
2010–2011	3 187 879	674 572	21.2	17	0.025	64	35–101
2011–2012	3 100 277	728 190	23.5	40	0.055	140	92–198
2012–2013†	2 862 182	560 333	19.6	21	0.037	110	65–171

†Provisional data, model estimates not finalised.

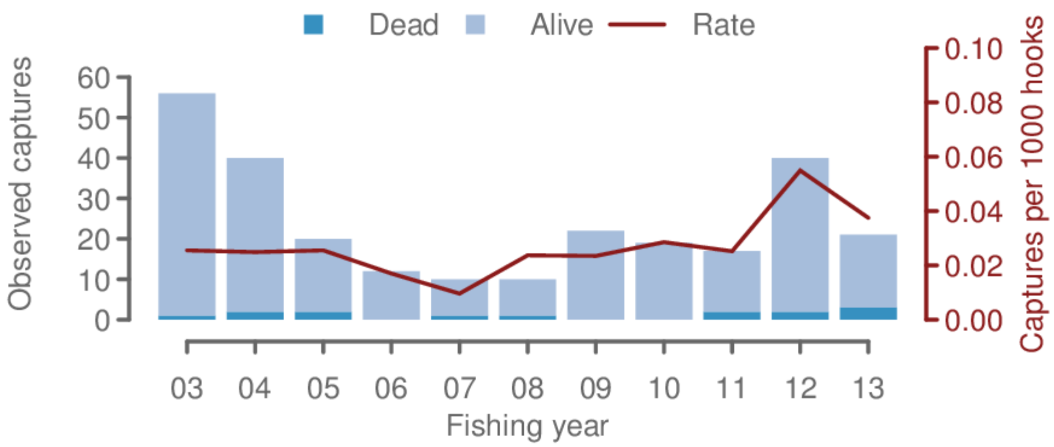


Figure 15: Observed captures of New Zealand fur seal in the New Zealand surface longline fisheries from 2002–03 to 2012–13.

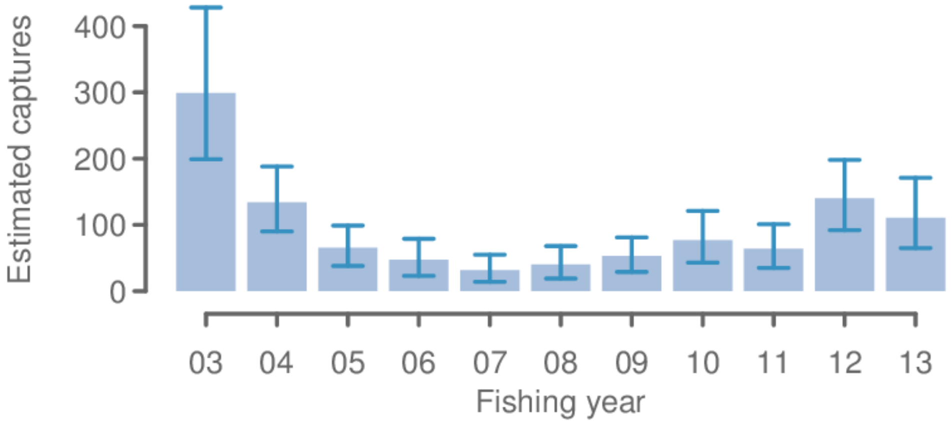


Figure 16: Estimated captures of New Zealand fur seal in the New Zealand surface longline fisheries from 2002–03 to 2012–13.

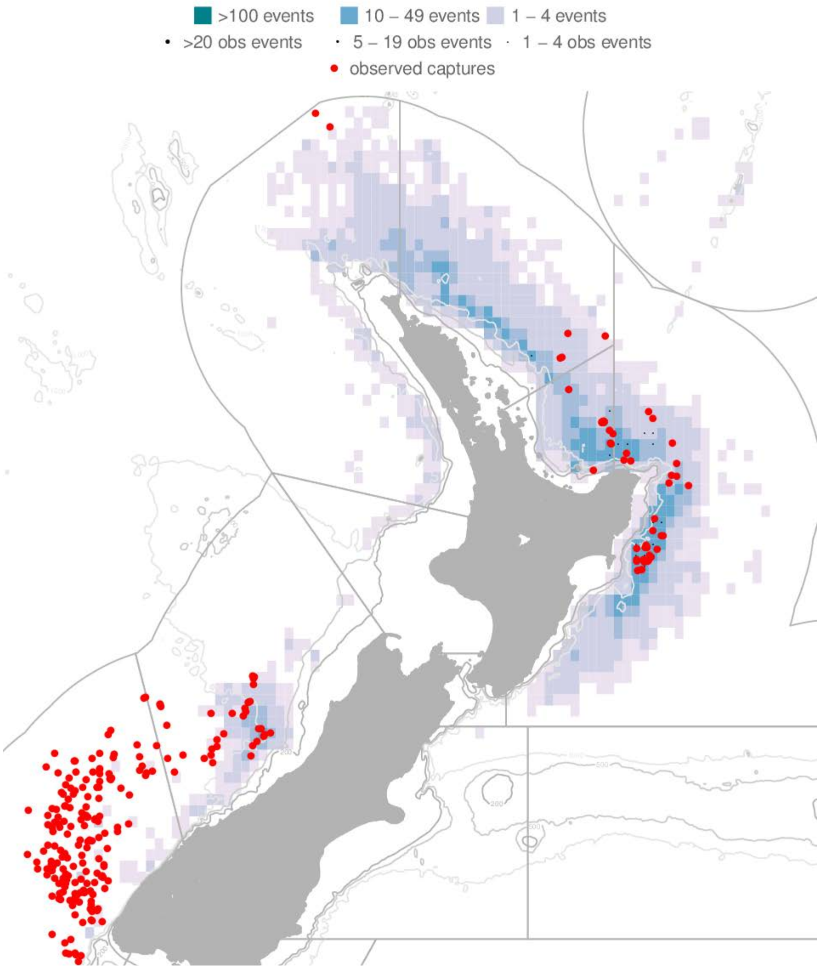


Figure 17: Distribution of fishing effort in the New Zealand surface longline fisheries and observed New Zealand fur seal captures, 2002–03 to 2012–13. Fishing effort is mapped into 0.2-degree cells, with the colour of each cell being related to the amount of effort. Observed fishing events are indicated by black dots, and observed captures are indicated by red dots. Fishing is only shown if the effort could be assigned a latitude and longitude, and if there were three or more vessels fishing within a cell. In this case, 89.4% of the effort is shown. See glossary for areas used for summarising the fishing effort and protected species captures.

4.3 Incidental fish bycatch

Observer records indicate that a wide range of species are landed by the longline fleets in New Zealand fishery waters. Blue sharks are the most commonly landed species (by number), followed by Lancetfish (Table14). Southern bluefin tuna and albacore tuna are the only target species that occur in the top five of the frequency of occurrence.

Table 14: Total estimated catch (numbers of fish) of common bycatch species in the New Zealand longline fishery as estimated from observer data from 2009 to 2013. Also provided is the percentage of these species retained (2013 data only) and the percentage of fish that were alive when discarded, N/A (none discarded).

Species	2010	2011	2012	2013	% retained (2013)	discards % alive (2013)
Blue shark	66113	53432	132925	158736	45.2	97.4
Lancetfish	43425	37305	7866	19172	0.1	37.6
Rays bream	20041	18453	19918	13568	97.4	4.2
Porbeagle shark	4679	9929	7019	9805	34.0	79.8
Mako shark	4490	9770	3902	3981	35.5	84.9
Moonfish	5398	3418	2363	2470	99.0	0.0
Escolar	1539	6602	2181	2088	30.2	76.3
Sunfish	3148	3773	3265	1937	2.7	100.0
Pelagic stingray	1983	4090	712	1199	1.0	97.0
Butterfly tuna	1158	909	713	1030	48.1	11.1
Deepwater dogfish	377	548	647	743	1.2	88.5
Oilfish	886	1747	509	386	26.5	72.2
Rudderfish	326	338	491	362	13.0	80.0
Thresher shark	209	349	246	256	33.3	75.0
Skipjack tuna	91	255	123	240	100.0	N/A
Dealfish	1160	223	372	237	1.7	25.1
Striped marlin	471	175	124	182	0.0	44.4
Big scale pomfret	505	139	108	67	88.2	100.0
School shark	62	49	477	21	100.0	N/A

4.4 Benthic interactions

N/A

4.5 Key environmental and ecosystem information gaps

Cryptic mortality is unknown at present.

Observer coverage in the New Zealand fleet has historically not been spatially or temporally representative of the fishing effort. However in 2013 the observer effort was re-structured to rectify this by planning observer deployment to correspond with recent spatial and temporal trends in fishing effort.

5. STOCK ASSESSMENT

With the establishment of the WCPFC in 2004, future stock assessments of the western and central Pacific Ocean stock of blue shark will be reviewed by the WCPFC.

Quantitative stock assessments of blue sharks outside the New Zealand EEZ have been mostly limited to standardised CPUE analyses, although quantitative assessment models have been developed using conventional age-structured and MULTIFAN-CL methods. An indicator analysis of blue sharks in New Zealand waters was conducted in 2014.

Results of these indicator analyses (Figures 18 and 19) suggest that blue shark populations in the New Zealand EEZ have not been declining under recent fishing pressure, and may have been increasing since 2005 (Table 15, Francis et al. 2014). These changes are presumably in response to a decline in SLL fishing effort since 2003 (Griggs & Baird 2013), and a decline in annual landings since a peak in 2001 for blue sharks. Observer data from 1995 suggest that blue sharks may have undergone a down-then-up trajectory. The quality of observer data and model fits means these interpretations are uncertain. The stock status of blue sharks may be recovering. Conclusive determination of stock status will require a regional (i.e. South Pacific) stock assessment.

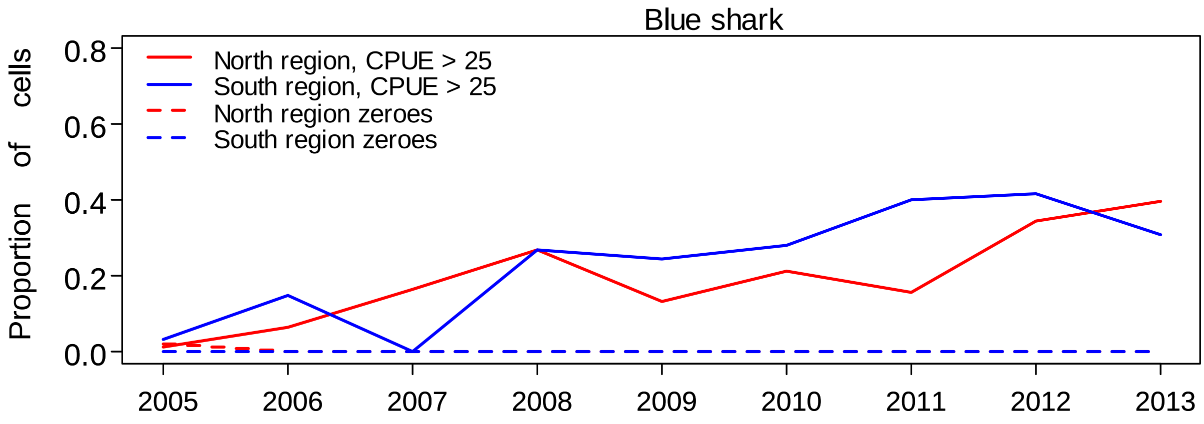


Figure 18. Blue shark distribution indicators. Proportions of 0.5 degree rectangles having CPUE greater than 25 per 1000 hooks, and proportions of rectangles having zero catches, for North and South regions by fishing year, based on estimated catches (processed and discarded combined) reported on TLCERs. North region comprises Fisheries Management Areas (FMAs) 1, 2, 8, and 9, and South region comprises FMAs 5 and 7.

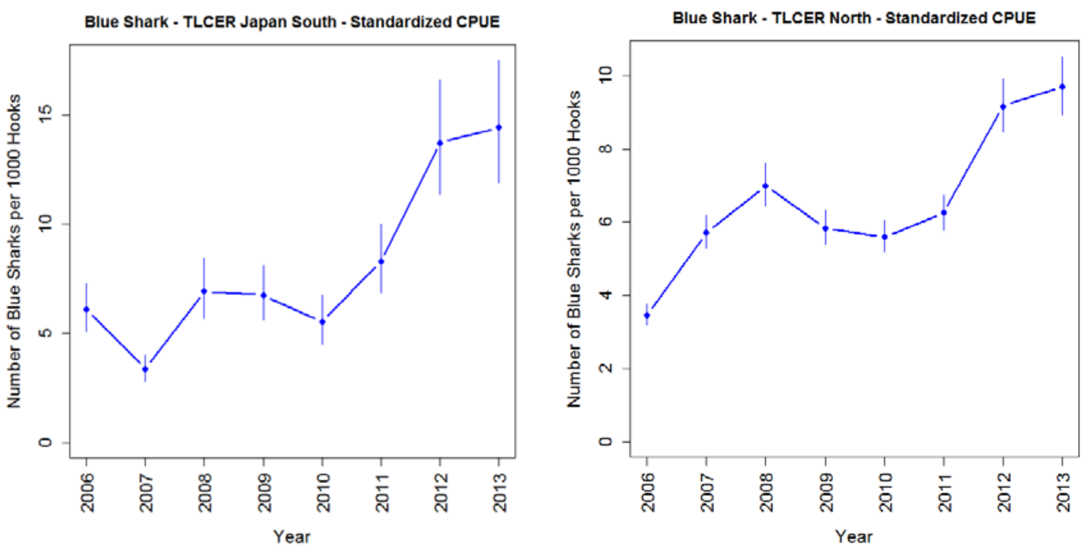


Figure 19: Standardised CPUE indices for commercial TLCER (Japan South and North) and observer datasets (all New Zealand) [Continued on next page].

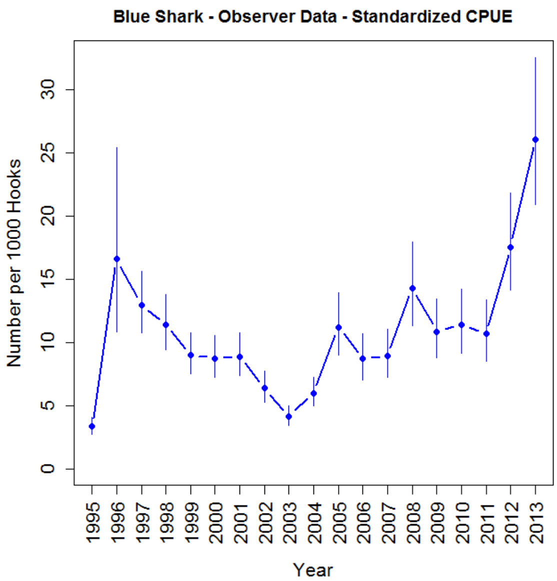


Figure 19 [Continued]: Standardised CPUE indices for commercial TLCER (Japan South and North) and observer datasets (all New Zealand).

Table 15: Summary of trends identified in abundance indicators since the 2005 fishing year based on both TLCER and observer data sets. The CPUE-Obs indicator was calculated for both North and South regions combined. North region comprises Fisheries Management Areas (FMAs) 1, 2, 8, and 9, and South region comprises FMAs 5 and 7. For the CPUE-TLCER indicator in South region, only the Japan dataset indicator is shown (the TLCER Domestic South dataset was small and probably unrepresentative). Green cells show indicators that suggest positive trends in stock size. Note that a downward trend in 'proportion-zeroes' is considered a positive stock trend. NA = indicator not applicable because of small sample size. Source: Francis et al. (2014).

		North region			South region		
Indicator class	Indicator	Blue	Porbeagle	Mako	Blue	Porbeagle	Mako
Distribution	High-CPUE	Up	Up	Up	Up	Up	NA
Distribution	Proportion-zeroes	Nil	Down	Down	Nil	Nil	Down
Catch composition	GM index total catch - TLCER	Up (all species)			Up (all species)		
Catch composition	GM index total catch - Obs	Up (all species)			Nil (all species)		
Catch composition	GM index HMS shark catch - TLCER	Up (all species)			Up (all species)		
Catch composition	GM index HMS shark catch - Obs	Up (all species)			Nil (all species)		
Standardised CPUE	CPUE - TLCER	Up	Nil	Up	Up	Nil	Nil
Standardised CPUE	CPUE - Obs	Up	Nil	Nil	Up	Nil	Nil
Sex ratio	Proportion males	Nil	Nil	Nil	Nil	Nil	NA
Size composition	Median length - Males	Nil	Nil	Nil	Nil	Nil	NA
Size composition	Median length - Females	Nil	Nil	Nil	Nil	Nil	NA

Blue sharks are the most heavily fished of the three large pelagic shark species (blue, mako, and porbeagle sharks) commonly caught in the tuna longline fishery. Compared to mako and porbeagle sharks, however, blue sharks are relatively fecund, fast growing, and widely distributed.

Observed length frequency distributions of blue sharks by area and sex are shown in Figure 20 for fish measured in 1993-2012. Length frequency distributions of blue sharks showed differences in size composition between North and South areas (Figure 20). There were more female blue sharks caught than males, with a higher proportion of females in the South than the North. Based on the length-frequency distributions and approximate mean lengths at maturity of 192.5 cm fork length for males and 180 cm for females (Francis & Duffy 2005), most blue sharks were immature (91.1% of males and 92.9% of females, overall). Greater proportions of mature male blue sharks were found in the North (12.1% mature in the North and 1.1% in the south), while more similar proportions of mature females were found in the North and South (4.5% and 8.4% respectively).

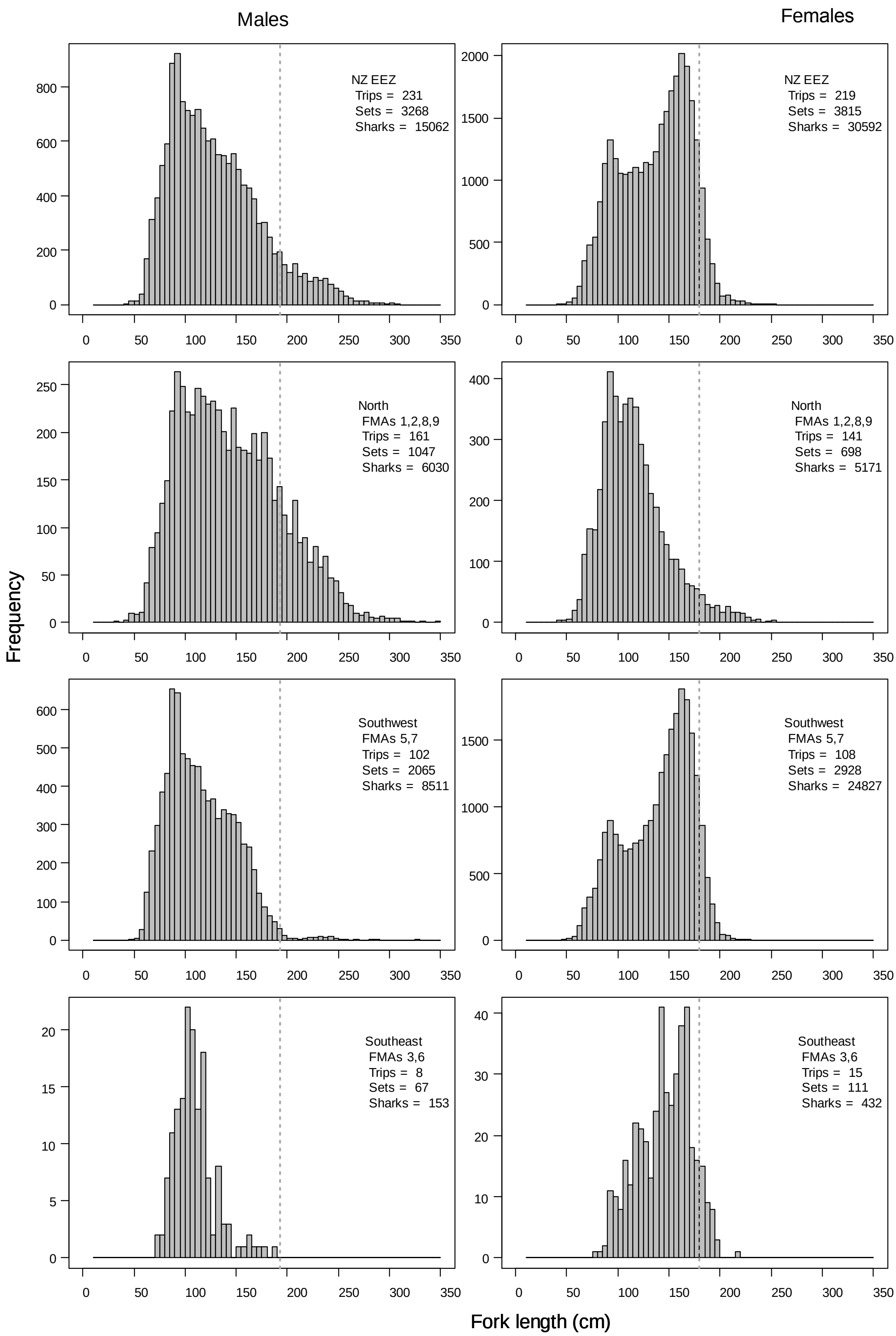


Figure 20: Length-frequency distributions of male and female blue sharks measured by observers aboard surface longline vessels between 1993 and 2012 for the New Zealand EEZ, and North, Southwest and Southeast regions. The dashed vertical lines indicate the median length at maturity. Source: Francis (2013).

6. STATUS OF THE STOCK

Stock structure assumptions

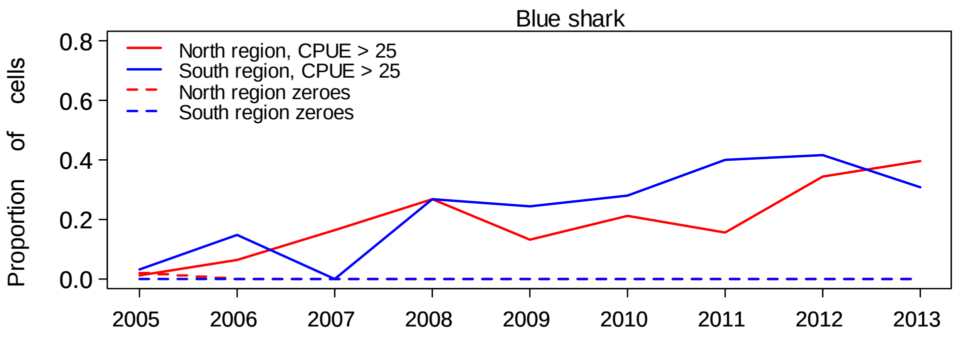
BWS 1 is assumed to be part of the wider South Western Pacific Ocean stock. However, there is no stock assessment for this wider stock. The results below are from an indicator analyses of the New Zealand component of that stock only.

Stock Status	
Year of Most Recent Assessment	2014
Assessment Runs Presented	Indicator analyses only for NZ EEZ
Reference Points	Target: Not established Soft Limit: Not established but HSS default of 20% SB_0 assumed Hard Limit: Not established but assume HSS default of 10% SB_0 assumed Overfishing threshold: F_{MSY}
Status in relation to Target	Unknown
Status in relation to Limits	Unknown
Status in relation to Overfishing	Unknown

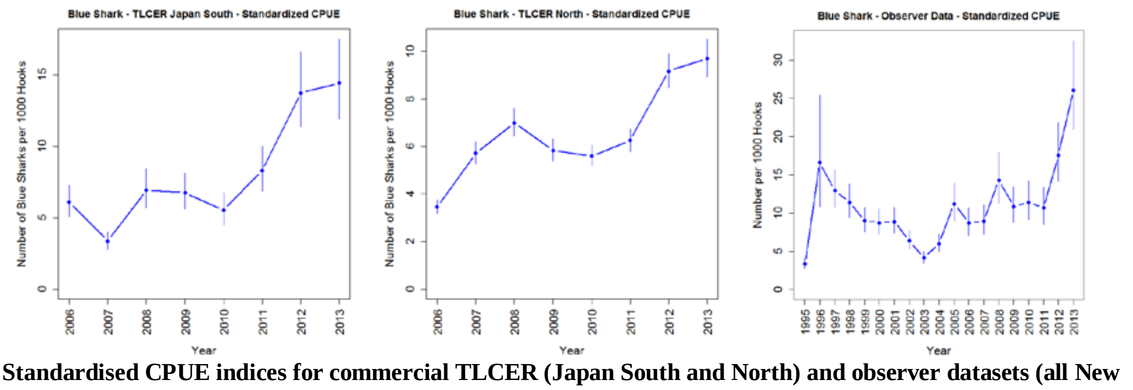
Historical Stock Status Trajectory and Current Status

Summary of trends identified in abundance indicators since the 2005 fishing year based on both TLCER and observer data sets. North region comprises Fisheries Management Areas (FMAs) 1, 2, 8, and 9, and South region comprises FMAs 5 and 7.

		North region			South region		
Indicator class	Indicator	Blue	Porbeagle	Mako	Blue	Porbeagle	Mako
Distribution	High-CPUE	Up	Up	Up	Up	Up	NA
Distribution	Proportion-zeroes	Nil	Down	Down	Nil	Nil	Down
Catch composition	GM index total catch - TLCER	Up (all species)			Up (all species)		
Catch composition	GM index total catch - Obs	Up (all species)			Nil (all species)		
Catch composition	GM index HMS shark catch - TLCER	Up (all species)			Up (all species)		
Catch composition	GM index HMS shark catch - Obs	Up (all species)			Nil (all species)		
Standardised CPUE	CPUE - TLCER	Up	Nil	Up	Up	Nil	Nil
Standardised CPUE	CPUE - Obs	Up	Nil	Nil	Up	Nil	Nil
Sex ratio	Proportion males	Nil	Nil	Nil	Nil	Nil	NA
Size composition	Median length - Males	Nil	Nil	Nil	Nil	Nil	NA
Size composition	Median length - Females	Nil	Nil	Nil	Nil	Nil	NA



Blue shark distribution indicators. Proportions of 0.5 degree rectangles having CPUE greater than 25 per 1000 hooks, and proportions of rectangles having zero catches, for North and South regions by fishing year, based on estimated catches (processed and discarded combined) reported on TLCERs. North region comprises Fisheries Management Areas (FMAs) 1, 2, 8, and 9, and South region comprises FMAs 5 and 7.



Standardised CPUE indices for commercial TLCER (Japan South and North) and observer datasets (all New Zealand).

Fishery and Stock Trends	
Recent Trend in Biomass or Proxy	Appears to be increasing
Recent Trend in Fishing Intensity or Proxy	Appears to be decreasing
Other Abundance Indices	-
Trends in Other Relevant Indicator or Variables	Catches in New Zealand increased from the early 1990s to a peak in the early 2000s but declined slightly in the mid 2000s and have remained relatively stable since that time.

Projections and Prognosis		
Stock Projections or Prognosis	The stock is likely to increase if effort remains at current levels	
Probability of Current Catch or TACC causing Biomass to remain below or to decline below Limits	Soft Limit: Unknown Hard Limit: Unknown	
Probability of Current Catch or TACC causing Overfishing to continue or to commence	Unknown	
Assessment Methodology and Evaluation		
Assessment Type	Level 2 – Partial Quantitative Stock Assessment: Standardised CPUE indices and other fishery indicators	
Assessment Method	Indicator analyses	
Assessment Dates	Latest assessment: 2014	Next assessment: Unknown
Overall assessment quality rank	1 – High Quality	
Main data inputs (rank)	-Distribution -Species composition -Size and sex ratio -Catch per unit effort	1 – High quality
Data not used (rank)	N/A	
Changes to Model Structure and Assumptions	-	
Major Sources of Uncertainty	Historical catch recording may not be accurate.	

Qualifying Comments
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Fishery Interactions
Interactions with protected species are known to occur in the longline fisheries of the South Pacific, particularly south of 25°S. Seabird bycatch mitigation measures are required in the New Zealand and Australian EEZs and through the WCPFC Conservation and Management Measure CMM2007-04. Sea turtles are also incidentally captured in longline gear; the WCPFC is attempting to reduce sea turtle interactions through Conservation and Management Measure CMM2008-03.

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DREDGE OYSTER (OYU 5)-Foveaux Strait

(*Ostrea chilensis*)

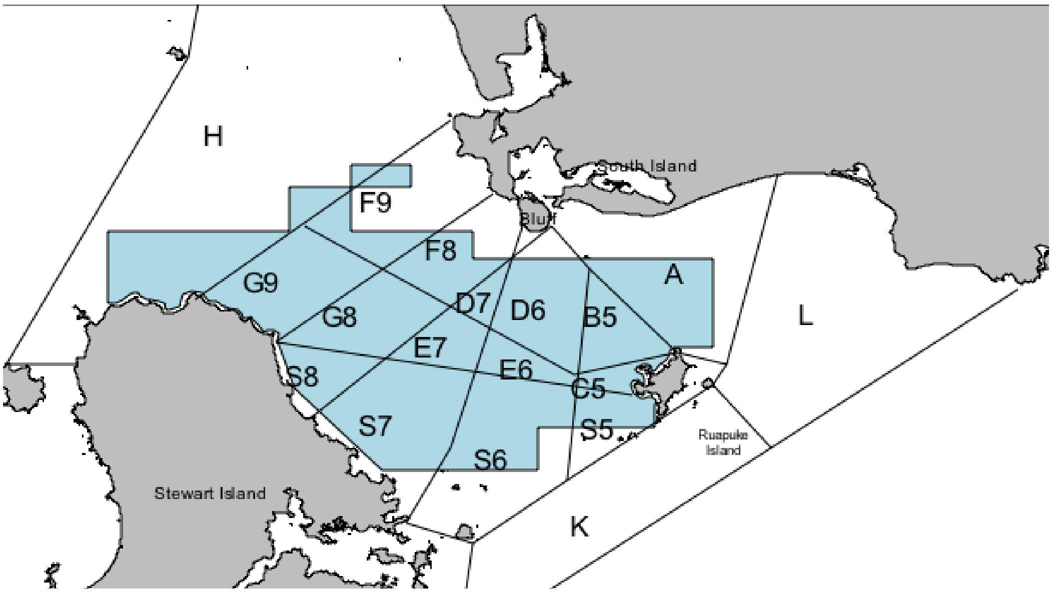


Figure 1: Foveaux Strait (OYU 5) stock boundary and oyster fishery statistical reporting areas, and the outer boundary of the 2007 stock assessment survey area (blue shade) encompassing almost all the commercial fishery.

1. FISHERY SUMMARY

The Foveaux Strait oyster fishery OYU 5 was introduced into the Quota Management System in 1998, with a TAC of 20 300 000 million oysters (Table 1).

Table 1: Total Allowable Catch (TAC) in numbers of oysters, and allocations for customary and recreational catch, for OYU 5 since the stock's introduction into the QMS in 1998. There were no estimates of other mortality (–).

Year	TAC	Customary	Recreational	Other Mortality	TACC
1998 – present	20 300 000	144 000[1]	430 000[1]	–	14 950 000

[1] Dunn, A. (2005)

1.1 Commercial fishery

The Foveaux Strait dredge oyster fishery has been fished for over 140 years. From the late 1880s to 1962 the fishery was managed by limiting the number of vessels licensed to fish. During this period vessel numbers varied between 5 and 12. The fishery was de-licensed in 1962 and boat numbers increased to 30 by 1969. Boundaries of statistical areas for recording catch and effort were established in 1960 and the outer boundary of the licensed oyster fishery was established in 1979. The western fishery boundary in Foveaux Strait is a line from Oraka Point to Centre Island to Black Rock Point (Codfish Island) to North Head (Stewart Island). The eastern boundary is from Slope Point, south to East Cape (Stewart Island). The OYU 5 stock boundaries and statistical reporting areas are shown in Figure 1.

Catch limits were introduced in 1963. In 1970, vessel numbers were limited to 23 by regulation. The catch limits were evenly divided between the 23 vessels. Before 1992, landings and catch limits in this fishery were recorded in sacks. Sacks contained an average of 774 oysters and weighed about 79 kg. Catch and effort has been traditionally recorded in sacks per hour dredged. Total landings of oysters between the 1880s and 1962 ranged between 15 and 77 million oysters. Reported landings for the period 1907–1962 are shown in Table 2. Catch limits and total landings for 1963–92 are shown in Table 3.

Table 2: Reported landings of Foveaux Strait oysters 1907–1962 (millions of oysters; sacks converted to numbers using a conversion rate of 774 oysters per sack). (Data summarised by Dunn, (2005) from Marine Department Annual Reports).

Year	Catch	Year	Catch	Year	Catch	Year	Catch	Year	Catch
1907	18.83	1919	16.56	1931	28.28	1943	56.59	1955	60.84
1908	17.34	1920	20.67	1932	29.01	1944	49.50	1956	58.63
1909	19.19	1921	19.01	1933	32.64	1945	58.85	1957	60.14
1910	18.20	1922	21.11	1934	40.44	1946	69.16	1958	64.44
1911	18.90	1923	22.28	1935	38.48	1947	63.09	1959	77.00
1912	19.00	1924	18.42	1936	49.08	1948	73.10	1960	96.85
1913	26.26	1925	20.01	1937	51.38	1949	75.34	1961	84.30
1914	19.15	1926	21.54	1938	52.05	1950	58.09	1962	53.42
1915	25.42	1927	16.26	1939	58.16	1951	70.15		
1916	22.61	1928	30.03	1940	51.08	1952	72.51		
1917	17.20	1929	30.44	1941	57.86	1953	55.44		
1918	19.36	1930	33.11	1942	56.87	1954	51.29		

Table 3: Reported landings and catch limits for the Foveaux Strait dredge oyster fishery from 1963–1992 (millions of oysters; sacks converted to numbers using a conversion rate of 774 oysters per sack). Catch rate shown in sacks per hour. (Data summarised by Dunn, (2005) from Marine Department Annual Reports).

Year	Reported landings		Catch limit	Catch rate	Year	Reported Landings		Catch limit	Catch rate
1963	58		132	6.0	1978	96	2	89	17.1
1964	73		132	6.8	1979	88		89	16.6
1965	95		132	7.9	1980	88		89	15.2
1966	124		132	10.6	1981	89		89	13.4
1967	127		132	9.3	1982	88		89	13.2
1968	114		121	7.7	1983	89		89	12.3
1969	51		94	6.5	1984	89		89	13.8
1970	88		89	7.3	1985	82		89	12.1
1971	89		85	6.9	1986	60	3	89	10.5
1972	77		85	6.7	1987	48	4	50	10.9
1973	97	1	85	10.0	1988	68		71	10.0
1974	92	1	85	11.5	1989	66		89	10.7
1975	89		89	11.9	1990	36		36	6.4
1976	89		89	13.4	1991	42	5	36	5.8
1977	92	2	89	15.9	1992	5	6	14	3.4

1 Landings include catch given as incentive to explore 'un-fished' areas.
2 Landings include catch given as an incentive to fish Area A.
3 Season closed early after diagnosis of *B. exitiosa* infection confirmed.
4 Catch limit reduced by the proportion of the fishery area with oysters infected by *B. exitiosa* and closed.
5 Landings include catch given as an incentive to fish a 'firebreak' to stop the spread of *B. exitiosa*.
6 Fishing only permitted in outer areas of fishery.

In 1986, *Bonamia exitiosa* (bonamia) was identified as the cause of high mortality in the oyster population and the epizootic reduced oyster density, and the size and number of commercial fishery areas over the next six years (see Cranfield et al. 2005, Doonan et al. 1994). Over that period, management of the fishery used changes to catch limits (Table 3) and spatial fishing strategies to minimize the effects of disease mortality and the spread of infection. In 1993 the oyster fishery was closed to allow the population to recover. The fishery was reopened in 1996 with a catch limit of 14.95 million oysters. This catch limit was converted to a catch quota of 1475 t using a conversion factor of 801 oysters per 79 kg sack, based on Bluff Oyster Enhancement Company data. From 1996, catches were recorded as numbers of oysters. Catch limits and total landings for 1996 to the present are shown in Table 4. Another *B. exitiosa* epizootic confirmed in March 2000 caused a decline in the oyster population and further reduced landings from 2003 (Table 4). Between 2003 and 2008, the Bluff Oyster Management Company (BOMC) shelved half of the TACC, harvesting about 7.5 million oysters annually. In 2011, the population size was continuing to increase and BOMC began to slowly reduce the level of shelving.

The Bluff Oyster Enhancement Company Ltd (BOEC) was established in 1992 to facilitate an oyster enhancement programme in attempts to rebuild the OYU 5 stock back to its pre-1985 level. In 1997, BOEC was renamed the Bluff Oyster Management Company Limited (BOMC), which became a commercial stakeholder organisation (CSO) to represent the combined interests of owners of individual transferable quota (ITQ) shares in the Bluff Oyster fishery (OYU 5). In April 1997, individual quotas were granted, and quota holders were permitted to fish their entire quota on one vessel. The quota shares were evenly allocated based on the 23 vessel licences. Soon after, the numbers of vessels in the fleet declined from 23 to 11. At the same time, the Crown purchased 20% of the available quota from quota holders by tender from willing sellers and transferred it to the Waitangi Fisheries Commission.

The commercial fishing year for the oyster fishery is from 1 October to 30 September however, oysters have been traditionally harvested over a six-month season, 1 March to 31 August. Commercial and recreational fishery data is reported by calendar year and customary fishing by fishing year (1 October to 30 September) as customary permits are issued out of season.

Table 4: Reported landings and catch limits for the Foveaux Strait dredge oyster fishery from 1996–to present. TACC was 14.95 million oysters over this period. Landings and catch limits reported in numbers (millions) of oysters. Reported catch rate based on number of sacks landed in CELR data, and revised catch rate based on numbers of oysters landed and converted to sacks (774 oysters per sack). Catch rate does not include oysters taken by crew as recreational catch. The numbers of oysters per sack can vary considerably (720–800 per sack, industry data) depending on the fishery areas from which they were caught, the sizes of oysters in these areas, and, and epifauna attached. Some oysters are landed in bins, and bins converted to sacks using a conversion factor of 0.5. Since 2009, fishers have been paid to high-grade the catch and they fish in areas where oyster meat quality is high, but catch rates are lower than for other areas with higher oyster densities, but with lower meat quality. CPUE from 2009 underestimates relative abundance. [Continued on next page]

Year	Reported landings	Catch limit including voluntary Catch limits from 2003	Reported catch rate	Revised catch rate
1996	13.41	14.95	5.9	5.8
1997	14.82	14.95	7 0	7.0
1998	14.85	14.95	8.3	6.7
1999	14.94	14.95	7.5	6.8
2000	14.43	14.95	7.2	6.4
2001	15.11	14.95	7.0	6.8
2002	14.45	14.95	3.2	3.3
2003	7.46	7.475 [1]	2.3	2.6
2004	7.48	7.475 [1]	2.2	2.5
2005	7.57	7.475 [1]	1.7	1.8
2006	7.44	7.475 [1]	1.9	1.9
2007	7.37	7.475 [1]	2.2	2.4
2008	7.49	7.475 [1]	3.3 [2]	3.3

Table 4 [Continued]:

2009	8.22	8.22 [3]	3.9 [2,4]	3.0
2010	9.54	9.53	4.2 [2,4]	4.2
2011	10.6[5]	10.6[5]	4.2 [2,4]	4.1
2012	11.6	11.6	4.2 [2,4]	4.1
2013	13.2	13.2	5.5 [2,4]	5.5

1 Fifty percent of the TACC was shelved for the season
2 Fishers given incentive to sort above MSL to increase market value, and changes in sorting potentially result in lower catch rates compared to previous years.
3 BOMC unshelved 10% of their shelved quota.
4 Catch reported in bins and sacks, bins converted to sacks by a conversion factor of 0.5.
*5 Landings d*ata for 2011 includes 1.0 million oysters caught under a special permit for the Rugby World Cup.

The landings of oysters from OYU5 (millions of oysters) from 1995–96 to present are shown in Figure 2.

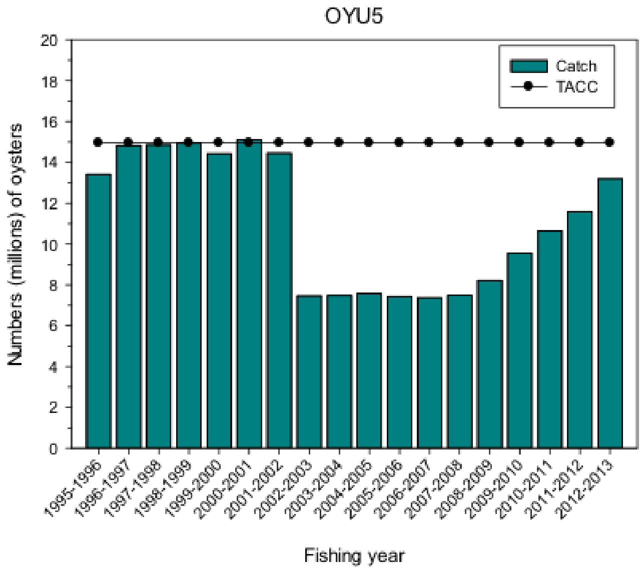


Figure 2: Landings of oysters from OYU 5 (millions of oysters) from 1995–1996 to 2011–2013.

1.2 Recreational fisheries

In 2002, Fisheries Officers estimated that between 70 and 100 recreational vessels were fishing from Bluff and smaller numbers from Riverton and Colac Bay. Recreational fishers may take 50 oysters per day during the open season (March–August). A charter boat fleet (approximately 17 vessels) based at Stewart Island, Bluff, and Riverton also targets oysters during the oyster season.

Four surveys of recreational fishing have been conducted to estimate recreational harvest: the South region 1991–92 survey, the 1996 survey (Bradford 1998), the 1999–2001 survey (MPI Recreational database), and the 2000–01 (MPI Recreational database) national telephone diary surveys. However, the catch of oysters cannot be reliably quantified from these surveys because of the small number of local respondents who reported catches of oysters in their diaries. The Southland Recreational Marine Fishers Association estimated that the annual recreational catch of oysters in Foveaux Strait in 1995 was about 300 000 oysters.

Table 5: Reported annual recreational catch (numbers of oysters) taken from commercial vessels March to August 2002–present (CELR data) and reported customary catch (numbers of oysters) October to September 1998–present (Tangata taiki data collected by Ngai Tahu).

Year	Recreational catch from commercial vessels els	Customary catch	
1998	N/A	143 940	1
1999	N/A	177 360	
2000	N/A	223 332	
2001	N/A	259 243	
2002	236 103	184 335	
2003	282 645	157 980	
2004	146 567	127 708	
2005	190 345	76 464	
2006	139 252	85 312	
2007	90 544	109 260	
2008	141 587	202 952	
2009	182 331	347 390	
2010	179 587	322 498	
2011	219 068	4 020	
2012	219 700	103 110	
2013	227 310	125 260	2

1 Customary catch reported for the period 1 July to 31 December only.
[2] Customary catch reported for the period 1 January to 30 September only

The commercial oyster fleet are a major contributor to the level of recreational harvest. Commercial fishers are entitled to 50 oysters each day (subject to approval under s111 of the Fisheries Act 1996), with each commercial vessel's crew potentially taking up to 400 oysters as recreational catch each day. Recreational catches from commercial vessels have, in the past, been reported on Catch and Effort Returns (CELR); and since 2002, have been separately reported on returns and not included in commercial catch effort statistics. Commercial fishers took 227310 oysters under recreational bag limits during the 2013 oyster season. Recreational catch taken on commercial vessels is shown in Table 5.

1.3 Customary non-commercial fisheries

Reporting of Maori customary harvest is specified in the Fisheries (South Island Customary Fisheries) Regulations 1999. Ngai Tahu administers the reporting of customary catch of Foveaux Strait oysters to the Ministry for Primary Industries. Customary catch is reported in the quarter it is summarized, landing dates are not reported for catches under customary permits. A small amount of customary fishing is believed to take place between 31 August and 30 September, and no customary permits are supposed to be issued for the quarter 1 October to 31 December while oysters are spawning. Reported customary catch for 1998 to 2013 is given in Table 5.

1.4 Illegal catch

There are no estimates of illegal catch for OYU 5.

1.5 Other Sources of Mortality

1.5.1 Mortality caused by *Bonamia exitiosa*

Bonamia exitiosa is a haemocritic, haplosporid parasite (infects mainly haemocytes or blood cells) of flat oysters. It is known to infect *Ostrea chilensis* in New Zealand and Chile; *Ostrea angasi* in Australia; *Ostrea puelchana* in Argentina; *Ostrea* (*Ostreola*) *conchaphila* in California, USA; *Ostrea edulis* in Atlantic Spain and probably in the Gulf of Manfredonia (Italy); *Ostrea* *stentina* in Tunisia, and possibly northern New Zealand (this isolate is also similar to *Bonamia. roughleyi*); and *Crassostrea ariakensis* in North Carolina, USA (Mike Hine, pers. comm.). Further, an unknown species of bonamia has been identified in two species of native oysters from Hawaii.

Mortality of oysters from *B. exitiosa* is a recurrent feature of the Foveaux Strait oyster population and the main driver of oyster abundance during epizootics. Large numbers of new clocks (shells of oysters that have died within six months) and oysters in poor condition (both indicative of *B. exitiosa* epizootics), were recorded as long ago as 1906. *B. exitiosa* has been identified in preserved oyster tissues sampled in 1964, at the end of an epizootic that caused a downturn in the fishery (Cranfield et al. 2005) and originally attributed to *Bucephalus longicornutus* (Hine & Jones 1994). A *B. exitiosa* epizootic occurred in the Foveaux Strait oyster fishery in 1986–92 and again in 2000–14. Prevalence of infection between 1996 and 2000 was not sampled, but is thought to be low (almost undetectable) from the low numbers of new clocks that were recorded in biennial oyster population surveys in that period.

The annual cycle of infection is described by Hine (1991). The parasite transmits directly, oyster to oyster, and disease spread is thought to be related to oyster density. Some oysters appear more tolerant of infection than others (Hine 1996). The relationship between the intensity and prevalence of infection in one year, the density of oysters, and the probability of oyster mortality the following year are poorly understood (Sullivan et al. 2005).

It is not known whether other diseases (including an apicomplexan, *Bucephalus* sp., coccidian, and microsporidian) contributed to or caused mortality in oysters during the 1986–92 and 2000–14 epizootics. No direct and immediate effect of oyster dredging on disease status can be determined.

Oyster mortality from bonamia is considerably higher than the commercial catch. Based on the number of oysters sampled with fatal infections during stock assessment surveys, the projected mortality of recruit-sized oysters between the surveys and the oyster seasons have been estimated at 43, 46, 81million oysters for years 2007, 2009, and 2012 respectively. Relatively small bonamia surveys were undertaken in years between stock assessment surveys in key commercial fishery areas, and these surveys did not estimate mortality from the whole population. In 2014, a new series of bonamia surveys began, sampling a core subset of strata which comprised 14 of the 26 stock assessment survey strata from 2012. These 14 strata represent 75% of the recruit-sized oyster population and 46% of the stock assessment survey area.

The 2014 bonamia survey found an overall increase in summer mortality of recruit-sized oysters. Oyster mortality over the summer of 2013–2014 was estimated from the sum of pre-survey mortality estimated from new clocks and gapers, and post survey mortality from the numbers of oysters in the population with fatal, category 3 and higher infections (see Diggles et al. 2003). Pre-survey mortality in core bonamia survey strata was 39.4 million oysters, and a further 44.7 million oysters in the remaining stock assessment strata (background strata). Fatal infections were projected to cause further mortality in 67.1 million oysters in core strata, and 122.4 million oysters for the whole survey area. The number of fatally infected oysters in core strata in 2014 was projected to reduce the recruit-sized oyster population from 538.0 million oysters at the time of the survey (February 2014) to 476.3 million oysters by early in the new oyster season (March 2014), a loss of 11.5%. A further 6.8% of the recruit-sized population died before the survey resulting in an annual summer mortality of 18.3%. This level of mortality is expected to produce a declining trend in the size of the population.

1.5.2 Incidental mortality caused by heavy dredges

Since 1965, heavy double bit, double ring bag dredges have been used in the Foveaux Strait oyster fishery. These dredges weighed around 410 kg when first introduced. Each oyster skipper fine tunes their dredges and current dredge weights range from 460 kg to 530 kg. These dredges are heavier than the single bit, single ring bag dredges employed between 1913 and 1964.

Incidental mortality of oysters from dredging with light (320 kg) and heavy (550 kg) dredges was compared experimentally in March 1997 (Cranfield et al. 1997). Oysters in the experiment had only a single encounter with the dredge. Numbers of dead oysters were counted seven days after dredging. The experiment found that mortality was inversely proportional to the size of oysters damaged and that lighter dredges damaged and killed fewer oysters. Recruit size oysters appeared to be quite robust (1–2% mortality) and few were damaged. Smaller oysters (10–57 mm in length) were less robust (6–8% mortality), but spat were very fragile and many were killed especially by the heavy commercial dredge (mortality of spat below 10 mm in height ranged from 19–36%). Incidental mortality from dredging may reduce subsequent recruitment in heavily fished areas but is unlikely to be important once oysters are recruited. The mortality demonstrated experimentally here has not been scaled to the size of the fishery and therefore its importance cannot be assessed.

2. BIOLOGY

Ostrea chilensis is a protandrous hermaphrodite that may breed all year round, but breeding peaks in the spring and summer months. Females produce few large (280–290 µm) yolky eggs, which after fertilisation continue to develop to pediveligers in the inhalant chamber for 18–32 days (depending on temperature). Most larvae are thought to settle immediately on release (at a size of 444–521 µm) and are thought to seldom disperse more than a few centimetres from the parent oyster. Some larvae are released early, at smaller sizes and spend some time in the plankton, and are capable of dispersing widely. Little is known about the timing and proportion of larvae released early in the plankton, and how this strategy may vary spatially and temporally, both within natal populations and the fishery. In Foveaux Strait, spat settlement is primarily during the summer months from December to February. Mean larval production of incubating oysters in Foveaux Strait was determined to be 5.09 $\times 10^4$ larvae, and only 6–18% of the sexually mature oysters spawned as females each year.

Little data are available on recruitment. Stock recruitment relationships for the Foveaux Strait dredge oyster are unknown, but most oysters surviving post settlement, are typically found on live oysters, and to a lesser extent, on oyster shells and on the circular saw *Astraea heliotropium* (Keith Michael, NIWA, pers. comm.). Generally, recruitment of sessile organisms is highly variable and often environmentally and predation driven (Cranfield 1979). About 2% of oyster spat survive the first winter; most mortality appears to result from predation by polychaetes, crabs, and small gastropods. Although settlement predominates on under-surfaces of oysters and shell, most surviving spat are attached to the left (curved and generally uppermost) valve of living oysters. Mean density of six month old oyster spat settled on spat plates at six sites in western and eastern Foveaux Strait over the summer of 1999–2000 was 1 700 m^2 (range 850–2 900 m^2) (Cranfield et al. unpublished data).

Growth rates of oysters varies between years and between areas of Foveaux Strait. Spat generally grow 5 to 10 mm in height by the winter after settlement. Mean height after one year is 18 to 25 mm, 25 to 35 mm after two years, 30 to 51 mm after three years, 40 to 65 mm after four years, and 65 to 75 mm after the fifth year. Oysters recruit to the legal-sized population (a legal-sized oyster will not pass through a 58 mm diameter ring, i.e., it must be at least 58 mm in the smaller of the two dimensions of height or length) at ages of 4–8 years. There is evidence for strong seasonal variation in growth (Dunn et al.1998b).

Dunn et al. (1998b) modelled the growth of a sample of oysters from four areas, grown in cages. Length-based growth parameters from this study are shown in Table 6.

Jeffs & Hickman (2000) estimated measures of maturity from the re-analysis of sectioned oyster gonads sampled at around monthly intervals from four sites in Foveaux Strait from April 1970 to April 1971. Analysis of these samples revealed that oysters were protandrous, maturing first as males at about 20 mm in shell height. Beyond 50 mm, most oysters developed ova while continuing to produce sperm, although oysters did not begin brooding larvae until 60 mm. Considerable quantities of ova were present in oysters throughout the year, but only a very small proportion of oysters spawned ova from July to December with a peak in October. Oysters commonly contained and released sperm throughout the year, although peak spawning was from November to March. The phagocytosis of reproductive material from the follicles of oysters was present in a small proportion of oysters throughout the year. However, it was much more common from January to March amongst both male and female reproductive material, including smaller (less than 50 mm), solely-male oysters.

Table 6: Estimates of biological parameters.

Fishstock	Estimate			Source
1. Natural mortality (*M*)				
OYU 5	0.042			Dunn et al. (1998b)
	Assumed 0.1			Allen (1979)
	Assumed 0.1			Dunn (2007)
2. Length-based growth parameters from Dunn et al. 1998a				

Length-based growth as estimated from model 3, is presented below. Growth is given for change in diameter.

$$\Delta l = (L_\infty - l1)(1 - e^{-k_{area + year}(\Delta t + \varphi)}) - \varepsilon$$

Estimated parameter values (and 95% confidence intervals)		
L	Area A	92.2 mm (86.7-
	Bird I.	76.2 mm (73.5-
	Lee Bay	77.8 mm (73.4-
	Saddle	81.0 mm (77.3-
Estimated parameter values (and 95% confidence intervals)		
k	1979	(reference year)
	1980	-0.29 (-0.33– -0.25)
	1981	0.02 (-0.02 – 0.06)
	Area A	0.48 (0.41-0.54)
	Bird I.	0.85 (0.76-0.94)
	Lee Bay	0.77 (0.68-0.86)
	Saddle	0.51 (0.50-0.52)
φ		-0.03

Fishstock	Estimate	Source
3. Size at sexual maturity (Females)		
50 mm diameter (49 mm		Cranfield & Allen (1979)
50 mm in length		Jeffs & Hickman (2000)
4. Percentage of population breeding as females annually		
Foveaux Strait	6-18%	Cranfield & Allen (1979)
Foveaux Strait	~50%	Jeffs & Hickman (2000)

3. STOCKS AND AREAS

The Foveaux Strait oyster fishery has been managed as a single stock, and current stock assessments are undertaken in a fishery area defined by the 2007 survey area. Oyster growth is "plastic" and influenced by habitat. Sub populations within the fishery have different morphological characteristics, but are considered a single genetic stock. There has been considerable translocation of oysters from Foveaux Strait to Fiordland and the Catlins to establish natal populations or supplement existing populations, but no records of reverse translocations.

4. STOCK ASSESSMENT

Surveys of the Foveaux Strait oyster population have been reported since 1906 (Dunn 2005) and see Sullivan et al. (2005) for details since 1960. Early surveys 1906, 1926–1945 are summarised by Sorensen (1968).

4.1 Estimates of fishery parameters and abundance

Estimates of fishery parameters used for stock assessment are given in Fu & Dunn (2009). CPUE data are used unstandardised. Fishery practices have changed from fishing for the highest catch rate to fishing for high meat quality at much lower catch rates to satisfy market requirements. These practices have resulted in more conservative estimates of CPUE and oyster density from catch and effort data. Interannual recruitment to the oyster population can vary markedly (Unpub. data). Oyster spat settle and survive almost exclusively on live oysters in Foveaux Strait.

4.2 Biomass Estimates

Before 2004 the Foveaux Strait oyster fishery was managed by current annual yield (CAY, Method 1, see Sullivan *et al.*2005) based on survey estimates of the population in designated commercial fishery areas. Since 2004, the TACC has been based on estimates of recruit-sized stock abundance from the Foveaux Strait oyster stock assessment model (Dunn 2005, 2007) and projections of future recruit-sized stock abundance under different catch limits and levels of mortality from *B. exitiosa*.

In 2004, Dunn (2005) presented a Bayesian, length-based, single-sex stock assessment model for Foveaux Strait dredge oysters using the general-purpose stock assessment program CASAL (Bull et al. 2005). That model was updated in 2007 (Dunn unpublished) to account for new data available, and a more complex variant of that model was also investigated. For more detailed information on the model structure, data and parameter inputs, sensitivity runs, results and discussion refer to Fu & Dunn (2009). The assessment was updated to include data up to the 2012 fishing year and the abundance indices from the February 2012 stock assessment survey.

The population model partitioned Foveaux Strait oysters into a single sex population, with length (i.e., the anterior-posterior axis) classes from 2 mm to 100 mm, in groups of 2 mm, with the last group defined as oysters at least 100 mm. The stock was assumed to reside in a single, homogeneous area. The partition accounted for numbers of oyster by length class within an annual cycle, where movement between length classes was determined by the growth parameters. Oysters entered the partition following recruitment and were removed by natural mortality (including disease mortality), and fishing mortality. The model’s annual cycle was divided into two time steps (Table 7).

Table 7: Annual cycle of the population model, showing the processes taking place at each time step, their sequence within each time step, and the available observations. Fishing and natural mortality that occur together within a time step occur after all other processes, with 50% of the natural mortality for that time step occurring before and 50% after the fishing mortality.

Step	Period	Process	Proportion in time step
1	Oct–Feb	Maturation	1.0
		Growth	1.0
		Natural mortality	0.5
		Fishing (summer) mortality	1.0
		B. exitiosa mortality	1.0
	Mar–Sep	Recruitment	1.0
		Natural mortality	0.5
		Fishing (winter) mortality	1.0

Oysters were assumed to recruit at age 1+, with a Beverton-Holt stock recruitment relationship (with steepness 0.9) and length at recruitment defined by a normal distribution with a mean of 15.5 mm and a CV of 0.4. Relative year class strengths were assumed to be known and equal to initial recruitment for the years up to 1984 — nine years before the first available length and abundance data on small oysters (less than 50 mm minimum diameter) and pre-recruits (oysters between 50 and 58 mm minimum diameter) were available; otherwise relative year class strengths were assumed to average 1.0. Growth rates and natural mortality (M) were assumed to be known. Disease mortality is assumed to be zero in the years where there were no reports of unusual mortality, and were otherwise estimated.

The models used seven selectivity ogives: the commercial fishing selectivity (assumed constant over all years and time steps of the fishery, aside from changes in the definition of legal size); a survey selectivity, which was then partitioned into three selectivities (one for each of the size-groups) small (less than 50 mm minimum diameter), pre-recruit (at least 50 mm but less than 58 mm minimum diameter), and recruit (at least 58 mm minimum diameter); maturity ogive; and disease selectivity assumed to follow a logistic curve equal to the maturity ogive. The selectivity ogives for fishing selectivity, maturity, and disease mortality were all assumed to be logistic. The survey selectivity ogives were assumed to be compound logistic with an additional parameter (amin) that describes the minimum possible value of the logistic curve. Selectivity functions were fitted to length data from the survey proportions-at-length (survey selectivities), and to the commercial catch proportions-at-length (fishing selectivity).

The maximum exploitation rate (i.e., the ratio of the maximum catch to vulnerable numbers of oysters in any year) was assumed to be relatively high, and was set at 0.5. No data are available on the maximum exploitation rate, but the choice of this value can have the effect of determining the minimum possible virgin stock size (B_0) allowed by the model.

The model was run for the years 1907–2010. Catch data were available for the years 1907–2010, with the catch for 2010 estimated to be 9.5 million oysters. Catches occurred in both time steps with special permit and some customary catch assigned to the first time step (summer fishing mortality), and commercial, recreational, remaining customary, and illegal catch assigned to the second time step (winter fishing mortality).

The priors assumed for most parameters are summarised in Table 8. In general, ogive priors were chosen to be non-informative and were uniform across wide bounds. The prior for disease mortality was defined so that estimates of disease mortality were encouraged to be low. An informed prior was used when estimating the survey catchability, where a reasonably strong lognormal prior was used, with a mean of 1.0 and a CV of 0.2.

Table 8: The priors assumed for key parameters. The parameters are mean and CV for lognormal (in natural space); and mean and s.d. for normal.

Parameter	Distribution	Parameters		Bounds	
CPUE *q*	Uniform-log	–	–	$1x10^{-8}$	0.1
1976 survey *q*	Lognormal	0.5	0.3	0.15	0.95
Mark-recapture survey *q*	Lognormal	0.5	0.3	0.10	0.90
YCS	Lognormal	1.0	1.0	0.01	100.0
Disease mortality	Normal	-0.2	0.2	0.00	0.80

4.2.1 Stock assessment results

Model estimates of numbers of oysters were made using the biological parameters and model input parameters described above. A full assessment in 2012 considered two model runs, the basic model and the revised model. The '2012 basic model' updated the basic model used in the 2009 assessment with catch and CPUE data for the 2010, 2011 and 2012 fishing years, the inclusion of the February 2012 biomass survey indices, and an assumed catch of 12.1 million oysters in 2012.

The ‘2012 revised model’ updated the 2009 revised model with similar input data. Table 9 describes the two model runs.

The basic model suggested the virgin equilibrium spawning stock population size to be about 3820 (3440–4290) million oysters, and the current spawning stock size to be 1170 (1060–1290) million oysters (Figure 3). The recruit-sized population was estimated at 1070 (960–1180) million.

Table 9: Model run labels and descriptions.

Model run	Description
2012 basic model	Growth parameters assumed fixed; annual disease rates estimated as independent variables; the disease selectivity was the same as the maturity ogive; Relative catchability *q* for the abundance surveys was fixed to be 1.
2012 revised model	Growth parameters estimated using tag-recapture data; annual disease rates assumed to be cubic-smooth; maturity and disease selectivity ogive decoupled; Estimated relative catchability *q* for the abundance surveys;

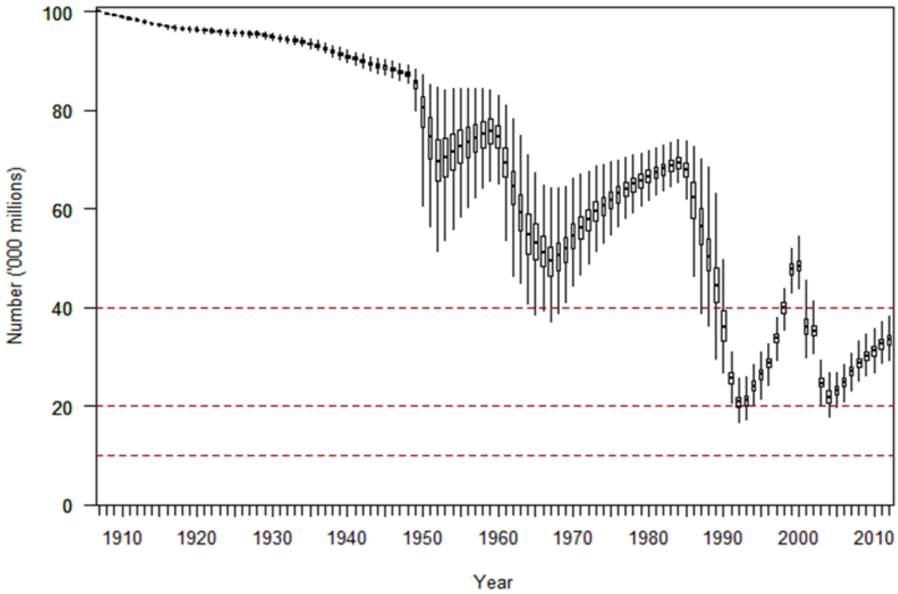


Figure 3: 2012 basic model estimated posterior distributions of SSB (as a percentage of B_0). Individual distributions show the marginal posterior distribution, with horizontal lines indicating the median.

The revised model run suggested a similar stock status as the basic model, with slightly higher productivity resulting from a slightly faster growth rate. The relative estimates of B_0 from these model runs suggested much greater variability in the estimates of the initial population size, but estimates of the current status and recent change in the current status were very similar (see Table 10). Applying a smoothing penalty to the estimated annual disease mortality rates had little impact on the key estimated parameters of the model.

Stock assessments planned every five years from 2012 will update these two models with data on catch history (total landings), unstandardised CPUE, commercial catch sampling for size structure, and abundance indices from population surveys. The new time series of annual bonamia surveys from 2014 (in years between stock assessments), will allow these models to be updated with total landings, catch rate, and catch size structure, and comparable estimates of population size (abundance indices) from the whole survey area.

The 2012 basic model update suggested the virgin equilibrium spawning stock population size to be about 3 510 (3 200−3870) million oysters, and the current spawning stock size to be 1 090 (990−1 210) million oysters (Table 10). The 2012 revised model suggested a similar virgin equilibrium spawning stock population size of 3 670 (3 350−4 050) million oysters, and a current spawning stock size of 1 130 (1 030−1 090) million oysters (Table 10).

Table 10: Bayesian median and 95% credible intervals of B_0 (millions) and SSBs (millions) for 2010 and 2012 from basic and revised models. The 2010 stock assessment partly updated the 2009 assessment with catch rate, total landings, and size structure from catch sampling, but there were no new estimates of population. The 2012 stock assessment updated the 2010 assessment with catch rate, total landings, and size structure from catch sampling, and new estimates of population size from the 2012 stock assessment survey.

Model	B_0	B_{2010}	B_{2012}
2012 basic model	3 510 (3 200−3 870)	1 090 (990−1 210)	1 170 (1 060−1 290)
2012 revised model	3 670 (3 350−4 050)	1 130 (1 030−1 090)	1 200 (1 090−1 330)

Projected stock estimates were made assuming that future recruitment will be log-normally distributed with a mean of 1.0 and standard deviation equal to the standard deviation of the log of recruitment between 1985 and 2010 (i.e., 0.34 with a 95% range of 0.29–0.39). Projections were made assuming no future disease mortality and with future disease mortality assumed to be 0.10 y^{-1} and 0.20 y^{-1}. Three future catch levels were considered each with 912.6 million oysters in 2012 and a future annual commercial catch of either 7.5, 15, or 20 million oysters. Future customary, recreational and illegal catch were assumed equal to levels assumed for 2012. Projected output quantities are summarised in Tables 11–14. The plot of the median expected recruit sized population is given in Figure 4.

Under the assumptions of future disease mortality, model projections of commercial catch at either 7.5, 15, or 20 million showed little difference in expected population size. For example, the projected population size in 2015 with a commercial catch of 7.5 million was less than 2% higher than that with a commercial catch of 20 million oysters. Depending on the level of assumed disease mortality, projected status in 2015 ranged from about 35% more than current levels (assuming no disease mortality) to a level about 34% less than the current level (assuming disease mortality of 0.2 y^{-1}) for the 2012 basic model, and from about 32% more than current levels (assuming no disease mortality) to a level about 24% less than the current level (assuming disease mortality of 0.2 y^{-1}) for the revised 2012 model.

Table 11: 2010 basic model median and 95% credible intervals of current spawning biomass 2012 (B_{2012}), and projected spawning stock biomass for 2013–15 (B_{2013}–B_{2015}) as a percentage of B_0 with an assumption of a future catch of 7.5, 15, or 20 million oysters in 2013–15, and disease mortality of 0.0, 0.1, or 0.2 y^{-1}.

Disease mortality	Catch (millions)	B_{2012} (% B_0)	B_{2013} (% B_0)	B_{2014} (% B_0)	B_{2015} (% B_0)
0	7.5	34.9 (30.6–41.1)	36.2 (29.3–44.4)	40.2 (32.5–50.3)	44.3 (35.6–55.6)
	15	34.9 (30.6–41.1)	36.2 (29.3–44.4)	40.0 (32.4–50.1)	44.0 (35.3–55.3)
	20	34.9 (30.6–41.1)	36.2 (29.3–44.4)	39.9 (32.2–50.0)	43.8 (35.0–55.1)
0.1	7.5	34.9 (30.6–41.1)	35.0 (28.4–43)	34.6 (28.0–43.6)	34.5 (27.4–43.9)
	15	34.9 (30.6–41.1)	35.0 (28.4–43)	34.5 (27.9–43.4)	34.2 (27.2–43.6)
	20	34.9 (30.6–41.1)	35.0 (28.4–43)	34.4 (27.8–43.3)	34.0 (27.0–43.4)
0.2	7.5	34.9 (30.6–41.1)	34.0 (27.6–41.8)	30.0 (24.1–37.9)	27.3 (21.5–35.5)
	15	34.9 (30.6–41.1)	34.0 (27.6–41.8)	29.9 (24.0–37.7)	27.1 (21.3–35.2)
	20	34.9 (30.6–41.1)	34.0 (27.6–41.8)	29.8 (23.9–37.6)	26.9 (21.2–35.1)

Table 12: 2012 basic model median and 95% credible intervals of expected recruit-sized stock abundance for 2012–15 with an assumption of a future catch of 7.5, 15, or 20 million oysters in 2013–15, and disease mortality rates of 0.0, 0.1, or 0.2 y^{-1}.

Disease mortality	Catch (millions)	rB_{2012}/rB_{2012}	rB_{2013}/rB_{2012}	rB_{2014}/rB_{2012}	rB_{2015}/rB_{2012}
0	7.5	1.00 (1.00–1.00)	1.05 (0.93–1.15)	1.18 (1.04–1.38)	1.32 (1.13–1.61)
	15	1.00 (1.00–1.00)	1.05 (0.93–1.15)	1.17 (1.03–1.37)	1.31 (1.12–1.59)
	20	1.00 (1.00–1.00)	1.05 (0.93–1.15)	1.17 (1.02–1.37)	1.30 (1.11–1.59)
0.1	7.5	1.00 (1.00–1.00)	0.97 (0.86–1.07)	0.94 (0.83–1.11)	0.94 (0.79–1.15)
	15	1.00 (1.00–1.00)	0.97 (0.86–1.07)	0.94 (0.82–1.11)	0.93 (0.78–1.14)
	20	1.00 (1.00–1.00)	0.97 (0.86–1.07)	0.93 (0.82–1.11)	0.92 (0.78–1.14)
0.2	7.5	1.00 (1.00–1.00)	0.90 (0.80–0.99)	0.97 (0.66–0.90)	0.67 (0.56–0.84)
	15	1.00 (1.00–1.00)	0.90 (0.80–0.99)	0.75 (0.66–0.90)	0.66 (0.55–0.83)
	20	1.00 (1.00–1.00)	0.90 (0.80–0.99)	0.75 (0.65–0.90)	0.66 (0.55–0.83)

Table 13: 2012 revised model median and 95% credible intervals of current spawning biomass 2012 (B_{2012}), and projected spawning stock biomass for 2013–15 (B_{2012}–B_{2015}) as a percentage of B_0 with an assumption of a future catch of 7.5, 15, or 20 million oysters in 2013–15, and disease mortality of 0.0, 0.1, or 0.2 y^{-1}

Disease mortality	Catch (millions)	B_{2012} (% B_0)	B_{2013} (% B_0)	B_{2014} (% B_0)	B_{2015} (% B_0)
0	7.5	34.5 (29.7-41.1)	36.5 (29.6-44.9)	40.6 (33.0-50.6)	44.6 (36-56.6)
	15	34.5 (29.7-41.1)	36.5 (29.6-44.9)	40.4 (32.8-50.5)	44.2 (35.7-56.3)
	20	34.5 (29.7-41.1)	36.5 (29.6-44.9)	40.3 (32.7-50.4)	44.0 (35.5-56.1)
0.1	7.5	34.5 (29.7-41.1)	35.6 (28.9-43.8)	36.1 (29.1-45.4)	36.5 (29.2-46.9)
	15	34.5 (29.7-41.1)	35.6 (28.9-43.8)	35.9 (29.0-45.3)	36.2 (29.0-46.7)
	20	34.5 (29.7-41.1)	35.6 (28.9-43.8)	35.6 (28.9-45.2)	36.0 (28.8-46.5)
0.2	7.5	34.5 (29.7-41.1)	34.7 (28.2-42.8)	32.1 (25.8-40.9)	30.3 (23.8-39.4)
	15	34.5 (29.7-41.1)	34.7 (28.2-42.8)	32.0 (25.7-40.7)	30.1 (23.5-39.2)
	20	34.5 (29.7-41.1)	34.7 (28.2-42.8)	31.9 (25.6-40.6)	30.0 (23.4-39.0)

Table 14: 2012 revised model median and 95% credible intervals of expected recruit-sized stock abundance for 2013–15 with an assumption of a future catch of 7.5, 15, or 20 million oysters in 2011–13, and disease mortality rates of 0.0, 0.1, or 0.2 y^{-1}.

Disease mortality	Catch (millions)	rB_{2012}/rB_{2012}	rB_{2013}/rB_{2012}	rB_{2014}/rB_{2012}	rB_{2015}/rB_{2012}
0	7.5	1.00 (1.00–1.00)	1.07(0.96-1.16)	1.20 (1.05-1.39)	1.35 (1.16-1.62)
	15	1.00 (1.00–1.00)	1.07 (0.96-1.16)	1.19 (1.04-1.39)	1.34 (1.14-1.61)
	20	1.00 (1.00–1.00)	1.07 (0.96-1.16)	1.19 (1.04-1.38)	1.33 (1.13-1.60)
0.1	7.5	1.00 (1.00–1.00)	1.00 (0.90-1.09)	1.00 (0.88-1.17)	1.02 (0.87-1.24)
	15	1.00 (1.00–1.00)	1.00 (0.90-1.09)	1.00 (0.87-1.17)	1.01 (0.86-1.23)
	20	1.00 (1.00–1.00)	1.00 (0.90-1.09)	1.00 (0.87-1.16)	1.00 (0.85-1.22)
0.2	7.5	1.00 (1.00–1.00)	0.94 (0.84-1.03)	0.84 (0.73-0.99)	0.78 (0.65-0.95)
	15	1.00 (1.00–1.00)	0.94 (0.84-1.03)	0.84 (0.73-0.99)	0.77 (0.64-0.94)
	20	1.00 (1.00–1.00)	0.94 (0.84-1.03)	0.83 (0.72-0.98)	0.76 (0.64-0.94)

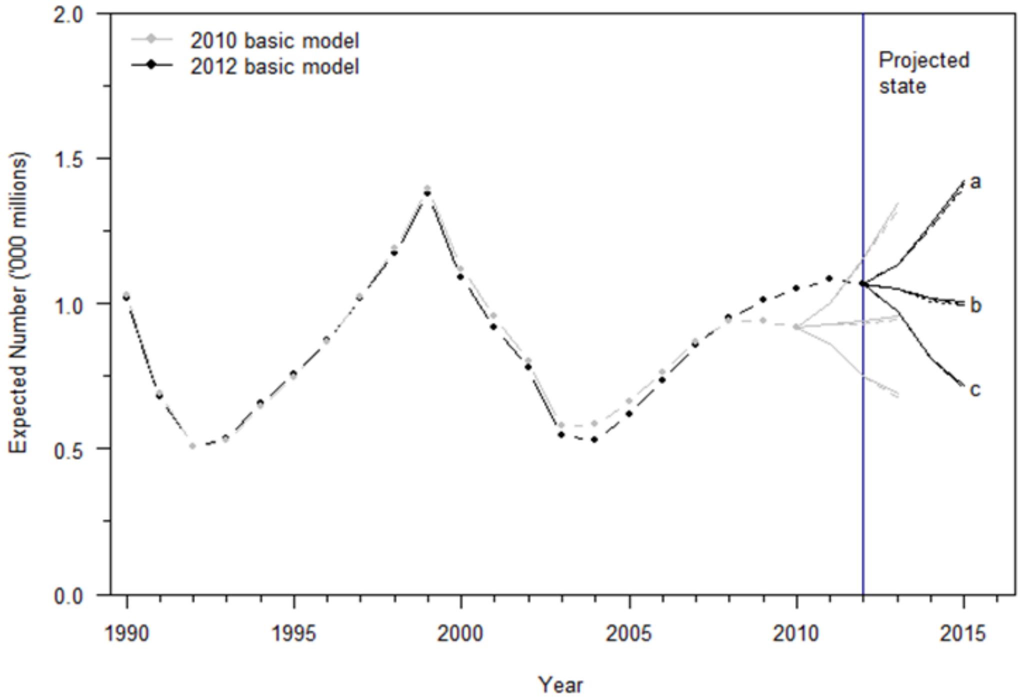


Figure 4: Model estimates of recent recruit-sized stock abundance and projected recruit-sized stock abundance for 2013–15 with catch of 7.5 (solid line), 15 (dash dot), and 20 million oysters (dashed line) under assumptions of (a) no disease mortality, (b) disease mortality of 0.10 y-1, and (c) disease mortality of 0.20 y-1 , for the 2010 and 2012 basic models. (top) and revised models for the same years respectively (bottom). [Continued on next page]

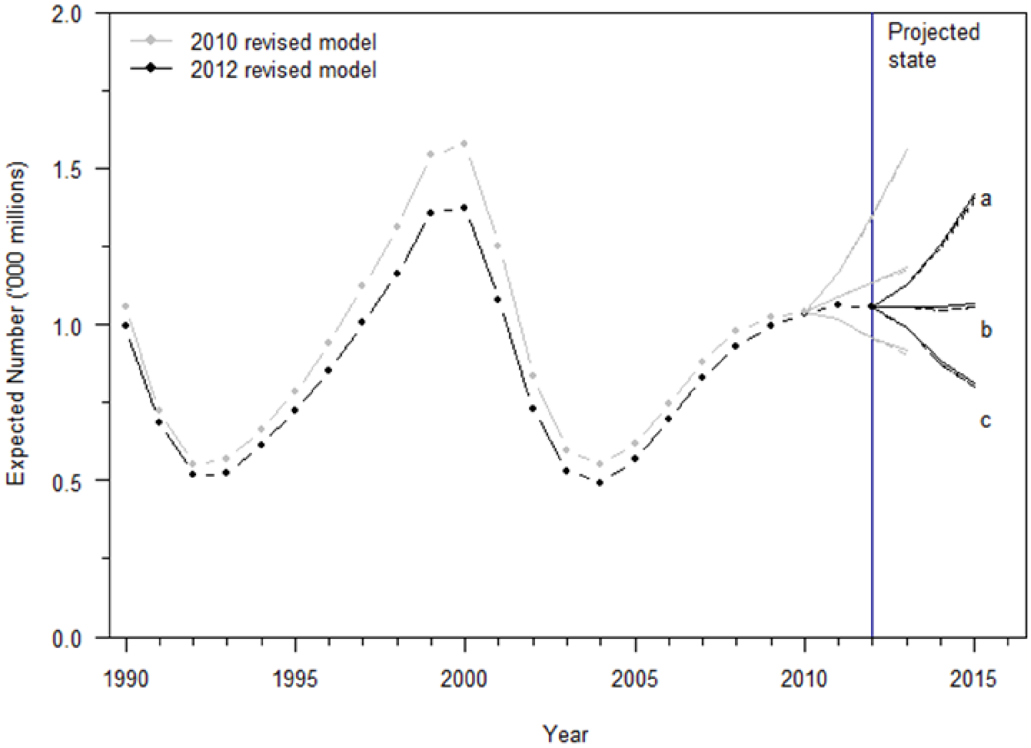


Figure 4 [Continued]: Model estimates of recent recruit-sized stock abundance and projected recruit-sized stock abundance for 2013–15 with catch of 7.5 (solid line), 15 (dash dot), and 20 million oysters (dashed line) under assumptions of (a) no disease mortality, (b) disease mortality of 0.10 y-1, and (c) disease mortality of 0.20 y-1 , for the 2010 and 2012 basic models. (top) and revised models for the same years respectively (bottom).

5. ENVIRONMENTAL AND ECOSYSTEM CONSIDERATIONS

This section was reviewed by the Aquatic Environment Working Group for inclusion in the Fishery Assessment Plenary November 2014. A broader summary of information on a range of issues related to the environmental effects of fishing and aspects of the marine environment and biodiversity of relevance to fish and fisheries is available in the Aquatic Environment & Biodiversity Annual Review (Ministry for Primary Industries 2013a).

5.1 Role in the ecosystem

Dredge oysters (*Ostrea chilensis*) are benthic, epifaunal, sessile bivalve molluscs that have a relatively limited pelagic larval dispersal phase. They are patchily distributed around the New Zealand coast on a variety of substrates (biogenic reef, gravel, sand, mud) in intertidal to subtidal inshore waters, commonly in depths of up to 60 m or more. Commercially exploited beds of oysters occur in Foveaux Strait (OYU 5), Tasman Bay (OYS 7), and Cloudy and Clifford Bays (OYS 7C). Beds at the Chatham Islands (OYS 4) have potential for commercial exploitation. Oysters play important roles in the ecosystem that include influencing water quality by filtering phytoplankton and other suspended particles from the seawater, linking primary production with higher trophic levels, and acting as ecosystem engineers by stabilising sediments and providing structural habitat (biogenic reef) for other taxa (e.g., algae, ascidians, bryozoans, sponges, echinoderms, worms, molluscs, crustaceans, fish).

5.1.1 Trophic interactions

Oysters are active suspension feeders, consuming phytoplankton suspended in the water column. Their diet is the same as or similar to that of many other suspension feeding taxa, including other bivalves such as scallops, clams, and mussels. Oysters are probably prey for a wide range of invertebrate and fish predators, but published records of known or suspected predators are limited. Reported invertebrate predators of *O. chilensis* include brittlestars (*Ophiopsammus maculata*) (Stead 1971), starfish (*Coscinasterias calamaria* and *Astrostole scabra*) (Cranfield 1979) and flatworms (*Enterogonia orbicularis*) (Handley 2002); suspected invertebrate predators include octopus (*Pinnoctopus cordiformis*) and shell boring gastropods (*Poirieria zelandica*, *Xymeme ambiguous*, and *Xymenella pusillis*) (Brown 2012). Predators of oysters probably change with oyster size. Most mortality of oyster spat (small juveniles) during their first winter appears to result from predation by polychaetes, crabs, and gastropods (Ministry for Primary Industries 2013b).

5.2 Incidental catch (fish and invertebrates)

A range of non-target fish and invertebrate species are caught and discarded by dredge fisheries for *O. chilensis*. No data are available on the level or effect of this incidental catch (bycatch) and discarding by the fisheries. Invertebrate bycatch data are available from dredge surveys of the oyster stocks, and the bycatch of the fisheries is likely to be similar to that of the survey tows conducted in areas that support commercial fishing. Fish bycatch data are generally not recorded on surveys, presumably because fish constitute a small fraction of the total bycatch.

In OYU 5 (Foveaux Strait), Cranfield et al. (1999) summarised the results of Fleming (1952) who sampled the macrofaunal bycatch of oyster fishing in a ‘near virgin’ area of the fishery in 1950; the bycatch was dominated by the frame-building bryozoan *Cinctipora elegans* (and oysters *O. chilensis*) and included a diverse range of other epifaunal organisms. More recently, presence-absence data on the bycatch of oyster dredging have been recorded during surveys and in fishers’ logbooks (Michael 2007). In a specific study of the benthic macrofauna bycatch of the 2001 oyster dredge survey in Foveaux Strait, Rowden et al. (2007) identified at least 190 putative species representing 82 families and 12 phyla; ‘Commercial’ survey strata were principally characterised by the families Balanidae (barnacles), Mytilidae (mussels), Ophiodermatidae (brittle stars), Ostreidae (oysters), and Pyuridae (tunicates). For the 2007 survey of OYU 5, Michael (2007) listed the percentage occurrence of sessile and motile species caught as bycatch in the survey dredge tows. The five most commonly caught sessile species (excluding oysters) were hairy mussels *Modiolus areolatus* (80% occurrence), barnacles *Balanus* sp. (61%), kina *Evechinus chloroticus* (61%), nesting mussels *Modiolarca impacta* (53%), and ascidians *Pyura pulla* (51%). The five most commonly occurring motile bycatch species were brittlestars *Ophiopsammus maculata* (90% occurrence), circular saw shells (gastropods) *Astraea heliotropium* (80%), hermit crabs *Pagurus novizelandiae* (80%), eight armed starfish *Coscinasterias muricata* (63%), and brown dipple starfish *Pentagonaster pulchellus* (54%). Common bycatch species of oyster dredge surveys in Foveaux Strait were reported by Michael (2007) and are listed below in Table 15.

Table 15: Invertebrate species commonly caught as bycatch in dredge surveys of oysters (*O. chilensis*) in Foveaux Strait. Sourced from Michael (2007). [Continued on next page]

Type	Species
Infaunal bivalves	*Glycymeris modesta* (small dog cockle), *Tawera spissa* (morning star shell), *Tucetona laticostata* (large dog cockle), *Pseudoxyperas elongata* (‘tuatua’), *Venericardia purpurata* (purple cockle)
Epifaunal bivalves	*Modioilus areolatus* hairy mussel), *Modiolarca impacta* (nesting mussel), *Aulacomya atra maoriana* (ribbed mussel), *Barbatia novaezelandiae* (ark shell), *Pecten novaezelandiae* (scallop), *Chlamys zelandiae* (lions paw scallop), *Neothyris lenticularis* (large lantern shell), *N. compressa* (compressed lantern shell)
Sponges	*Chondropsis* topsentii (cream sponge), *Crella incrustans* (red-orange sponge), *Dactylia palmata* (finger sponge)
Ascidians	*Pyura pachydermatina* (kaeo), *P. pulla*
Algae	Red algae spp.
Bryozoans	*Celleporaria agglutinans* (hard/plate coral), *Cinctipora elegans (reef-building bryozoan), Horera foliacea* (lace coral), *Hippomenella vellicata* (paper coral), *Tetrocycloecia neozelanica* (staghorn coral), *Orthoscuticella fusiformis* (soft orange bryozoan)
Barnacles and chitons	*Balanus decorus* (large pink barnacle), *Cryptochonchus porosus* (butterfly chiton), *Eudoxochiton nobilis* (noble chiton), *Rhyssoplax canaliculata* (pink chiton)

Table 15 [Continued]:

Starfish, brittlestars, and holothurians	*Coscinasterias muricata* (eight armed starfish), *Pentagonaster pulchellus* (brown dipple starfish), *Ophiosammus maculata* (snaketail brittlestar), *Australostichopus mollis* (sea cucumber)
Crabs	*Pagurus novaezelandiae* (hermit crab), *Eurynolambrus australis* (triangle crab), *Metacarcinus novaezelandiae* (cancer crab), *Nectocarcinus* sp. (red crab)
Urchins	*Evechinus chloroticus* (kina), *Apatopygus recens* (heart urchin), *Goniocidaris umbraculum* (coarse-spined urchin), *Pseudechinus novaezelandiae* (green urchin), *P. huttoni* (white urchin), *P. albocinctus* (red urchin)
Gastropods	*Astraea heliotropium* (circular saw shell), *Alcithoe arabica* (volute), *Argobuccinum pustulosum tumidum, Turbo granosus, Cabestana spengleri, Charonia lampras*
Octopuses	*Pinnoctopus cordiformis* (common octopus), *Octopus huttoni* (small octopus)

In OYS 7 (Tasman/Golden Bays), data on the bycatch of the 1994–2014 dredge surveys have been collected but not analysed, except for preliminary estimation of the 1998–2013 bycatch trajectories (Williams et al. 2014b). The surveys record the bycatch of other target species of scallops (*Pecten novaezelandiae*) and green-lipped mussels (*Perna canaliculus*), and various other non-target bycatch in nine categories (Williams et al. 2014b). Observation of the 2014 survey sampling identified a problem with the way these categorical bycatch data have been recorded which limits their utility (Williams et al. 2014a).

In OYS 7C, a dredge survey of oysters in Cloudy and Clifford Bays was conducted in 2006, and the survey skipper recorded qualitative comments on the bycatch of each tow, which included ‘coral’, ‘sticks and seaweed’, shells, volutes, ‘red weed’, horse mussels, shell with worm, small crabs, mussels, and scallop (Brown & Horn 2006).

In OYS 4 (Chatham Islands), data on the bycatch of a 2013 dredge survey of oysters off the north coast of Chatham Island were recorded (as estimated volumes of different bycatch categories) but not analysed (Williams et al. 2013).

5.3 Incidental catch (seabirds, mammals, and protected fish)
There is no known bycatch of seabirds, mammals or protected fish species from *O. chilensis* oyster fisheries.

5.4 Benthic interactions
There are a variety of benthic habitats in the different oyster fisheries areas, which generally occur either on coarse substrates usually found in areas of high natural disturbance (Foveaux Strait, Cloudy/Clifford Bays and the Chatham Islands) or on fine substrates typical of sheltered areas (Tasman Bay). Benthic habitats within the Foveaux Strait oyster fishery area were classified by Michael (2007) and comprise a variety of sand/gravel/shell flats and waves, rocky patch reef, and biogenic areas. Cranfield et al. (1999) referred to the latter as epifaunal reefs that he defined as ”tidally-oriented, linear aggregations of patch reefs formed by the bryozoan *Cinctipora elegans*, cemented by encrusting bryozoans, ascidians, sponges and polychaetes”. Cranfield et al.’s papers (Cranfield et al. 1999, Cranfield et al. 2001, Cranfield et al. 2003) suggested that epifaunal reefs are oyster habitat, but Michael’s reports (Michael 2007, 2010) state that commercial fishing for oysters is mainly based on sand, gravel, and shell habitats with little epifauna. In Foveaux Strait, commercial oyster dredging occurs within an area of about 1000 km^2 (although only a portion of this is dredged each year), which is about one-third of the overall OYU 5 stock area (Michael 2010). Habitats within the Cloudy/Clifford Bays and the Chatham Islands fisheries areas have not been defined. The benthic habitat within the Tasman Bay oyster fishery area is predominately mud, although to some extent this may have been affected by land-based sedimentation into the bay and homogenisation of the substrate by dredging and trawling (Brown 2012).

It is well known that fishing with mobile bottom contact gears such as dredges has impacts on benthic populations, communities, and their habitats (e.g., see Kaiser et al. 2006, Rice 2006). The effects are not uniform, but depend on at least: “the specific features of the seafloor habitats, including the natural disturbance regime; the species present; the type of gear used, the methods and timing of deployment of the gear, and the frequency with which a site is impacted by specific gears; and the history of human activities, especially past fishing, in the area of concern" (Department of Fisheries and Oceans 2006). In New Zealand, the effects of oyster dredging on the benthos have been studied in Foveaux Strait (OYU 5) (Cranfield et al. 1999, Cranfield et al. 2001, Cranfield et al. 2003, Michael 2007) and Tasman/Golden Bays (OYS 7) (Tuck et al. 2011). The results of these studies are summarised in the Aquatic Environment & Biodiversity Annual Review (Ministry for Primary Industries 2013a), and are consistent with the global literature: generally, with increasing fishing intensity there are decreases in the density and diversity of benthic communities and, especially, the density of emergent epifauna that provide structured habitat for other fauna.

The effects of dredging (Ministry for Primary Industries 2013a) may be more severe in sheltered areas (e.g., Tasman Bay) than in exposed areas (e.g., Foveaux Strait, Cloudy/Clifford Bays, Chatham Islands). Dredging damages epifauna, and erect, structured habitats, such as biogenic/epifaunal reefs, are the most sensitive to dredging disturbance. Dredging destabilises sediment/shell substrates, suspends sediments and increases water turbidity; the sensitivity of habitats to suspended sediments and their deposition probably varies depending on the prevailing natural flow regime, being greater in muddy sheltered areas than in high flow environments. Habitats disturbed by dredging tend to become simpler, more homogenous areas typically dominated by opportunistic species. Dredging generally results in reduced habitat structure and the loss of long-lived species.

For studies of the effects of oyster dredging in Foveaux Strait, interpretation of the authors differ (Ministry for Primary Industries 2013a): "Cranfield et al's papers (Cranfield et al. 1999, Cranfield et al. 2001, Cranfield et al. 2003) concluded that dredging biogenic reefs for their oysters damages their structure, removes epifauna, and exposes associated sediments to resuspension such that, by 1998, none of the original bryozoan reefs remained. Michael (2007) concluded that there are no experimental estimates of the effect of dredging in the strait or on the cumulative effects of fishing or regeneration, that environmental drivers should be included in any assessment, and that the previous conclusions cannot be supported. The authors agree that biogenic bycatch in the fishery has declined over time in regularly-fished areas, that there may have been a reduction in biogenic reefs in the strait since the 1970s, and that simple biogenic reefs appear able to regenerate in areas that are no longer fished (dominated by byssally attached mussels or reef-building bryozoans). There is no consensus that reefs in Foveaux Strait were (or were not) extensive or dominated by the bryozoan *Cinctipora*."

Some areas of the Foveaux Strait (OYU 5) oyster fishery are also commercially fished (potted) for blue cod (*Parapercis colias*), and Cranfield et al. (2001) presented some evidence to suggest that dredged benthic habitats and blue cod densities regenerated in the absence of oyster dredging. Bottom trawling also occurs within the OYU 5 area, but there is little overlap with the main areas fished for oysters. In OYS 7, other benthic fisheries (e.g. bottom trawl, scallop, green-lipped mussel) occur and probably also interact with oysters and their habitats.

5.5 Other considerations

5.5.1 Spawning disruption

Fishing during spawning may disrupt spawning activity or success. In the Foveaux Strait fishery, the traditional harvesting period (1 March to 31 August) occurs after the main spring and summer peaks in oyster spawning activity (Jeffs & Hickman 2000). Fishing-induced damage to oysters incurred during the period before spawning could interrupt gamete maturation. Oyster fishing also targets high-density beds of oysters, which are disproportionately more important for fertilisation success during spawning.

5.5.2 Habitat of particular significance for fisheries management

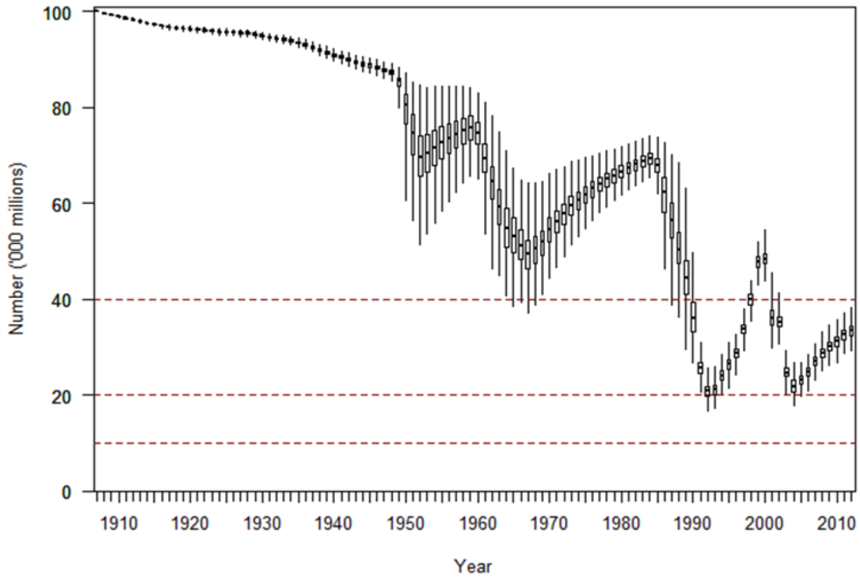
None currently identified.

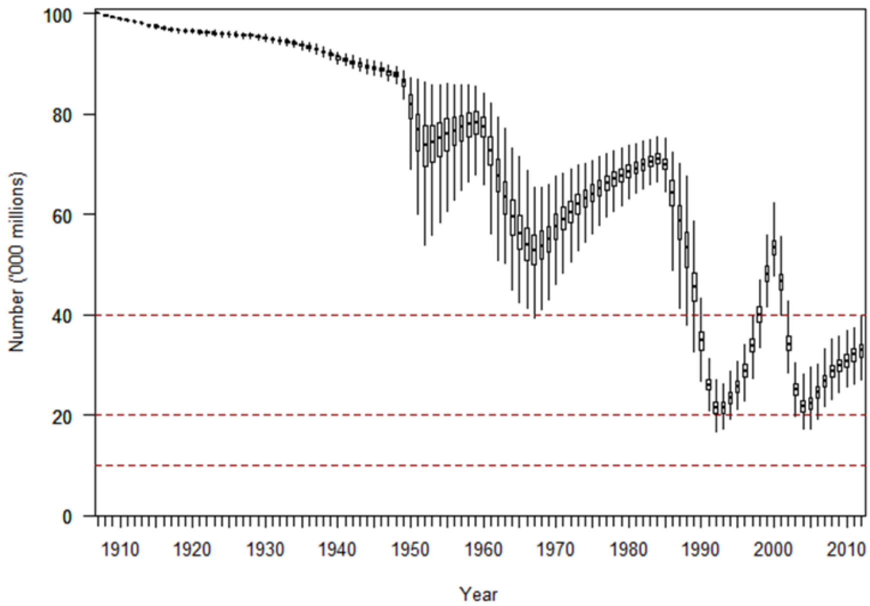
6. STATUS OF THE STOCKS

Stock Structure Assumptions
OYU 5 is assessed as a single stock defined by the survey boundaries.

Foveaux Strait Oysters OYU 5

Stock Status	
Year of Most Recent Assessment	2012
Assessment Runs Presented	Basic model (absolute biomass) and revised model (relative biomass)
Reference Points	Target(s): 40% B_0 Soft Limit: 20% B_0 Hard Limit: 10% B_0
Status in relation to Target	Unlikely (< 40%) to be at or above the target.
Status in relation to Limits	Model — B_0 — B_{2012} — $\%B_0$ 2012 basic — 3 510 — 1 090 — 31.1% 2012 revised — 3 670 — 1 130 — 30.1% Unlikely (< 40%) to be below the Soft Limit Very Unlikely (< 10%) to be below the Hard Limit.

Historical Stock Status Trajectory and Current Status




2012 basic model (top) and revised model (bottom) estimated posterior distributions of Spawning Stock Biomass (as a percentage of B_0). Individual distributions show the marginal posterior distribution, with horizontal lines indicating the median. Significant declines in population size are attributed to epizootics of *Bonamia exitisoa.*

Fishery and Stock Trends	
Recent Trend in Biomass or Proxy	Stock size reached a low point in 2005, which is near the historical minimum, but had increased until 2012. The 2014 Bonamia survey suggests a decline in the recruit-sized population. Commercial catch rates have remained relatively high.
Recent Trend in Fishing Mortality or Proxy	The TACC has been 14.95 million oysters since 1996. Bluff oyster management company shelved 50% of the ACE from 2003−2008, and since 2009 have progressively unshelved part of the 50% originally shelved. Landings have increased from 7.5 million oysters to 13.2 million in 2013.
Other Abundance Indices	Unstandardised catch and effort data are a good proxy for oyster density and reflect the status of commercial fishery areas. Commercial catch rates have been increasing since 2005 from annual means of 1.8 sacks per hour to 4.2 sacks per hour in 2012, and have increased further to 5.5 sacks per hour in 2013. The practice of high grading since 2009 has probably resulted in more conservative estimates of catch and effort that for the period before 2009.
Trends in Other Relevant Indicators or Variables	Since 2005, mortality from bonamia has been relatively low (less than10% of recruited oysters) recruitment to the fishery has exceeded *B. exitiosa* mortality, and the population size of recruited oysters had continued to increase until 2013. In 2014, bonamia infection was still widespread, but patchily distributed in the fishery area. Post survey mortality (11.5%) in February 2014 was markedly higher than the levels between 2008 and 2013: 6.9%, 3.3%, 6.3%, 6.6%, 6.7% and 8.8% respectively. Summer mortality in 2014 was 18.3%, and with recruitment to the population being lower than the long-term average, the recruit-sized oyster population is expected to decline in the short-term.
Projections and Prognosis	
Stock Projections or Prognosis	The 2012 stock assessment suggested that recruit-sized stock abundance was about 30% (26–34%) of B_0. By 2012, the trajectory of the future

	stock size was already starting to flatten due to the continuing low level of mortality from bonamia and reduced recruitment to the population since 2009. Bonamia mortality ranged from between 8% and 12% between 2007 and 2012. The population size of recruit-sized oysters in core strata declined by 21.8% over the two years between 2012 and 2014, and fatally infected oysters were expected to further reduce the population by 11.5% within one to two months. This level of bonamia mortality is expected to cause a downward trend in the oyster population, consistent with projection "c". A significant increase in recruitment could have a major restorative effect, but there will be a 4–6 year lag before any heightened recruitment to the population translates to recruitment to the fishery.	
Probability of Current Catch or TACC causing decline below Limits	While uncertainty exists in levels of future recruitment and continued *B. exitiosa* related mortality, projections from the Foveaux Strait oyster stock assessment model indicate that current catch limits are unlikely to have any significant negative effect on future stock levels.	
Assessment Methodology		
Assessment Type	Full five yearly, quantitative stock assessment with annual surveys.	
Assessment Method	Bayesian length based stock assessment model	
Assessment Dates	Latest assessment: Full in 2012	Next full assessment: 2017
Overall Assessment Quality (rank)	1 – High Quality	
Main data inputs (rank)	- catch history (total landings) - unstandardised CPUE - commercial catch length frequency sampling - abundance indices from population surveys	1 – High Quality 1 – High Quality 1 – High Quality 1 – High Quality
Changes to Model Structure and Assumptions	The model may be reviewed in the future	
Major Sources of Uncertainty	Stock size is highly dependent on the levels of mortality from bonamia and continued recruitment around the long-term average. Interannual and spatial variabilty in oyster growth rates may affect transitions of pre-recruit oysters to the recruited oyster population.	

Qualifying Comments
In the absence of disease mortality, the fishery has shown an ability to rebuild quickly at the level of the TACC. Reduced levels of recruitment to the oyster population believed to be environmentally driven may slow any rebuilding in the short-term.
Fishery Interactions
There is some overlap between oyster dredging and bottom trawling. Bycatch data are recorded from population and bonamia surveys, and in fishers' logbooks.

7. FOR FURTHER INFORMATION

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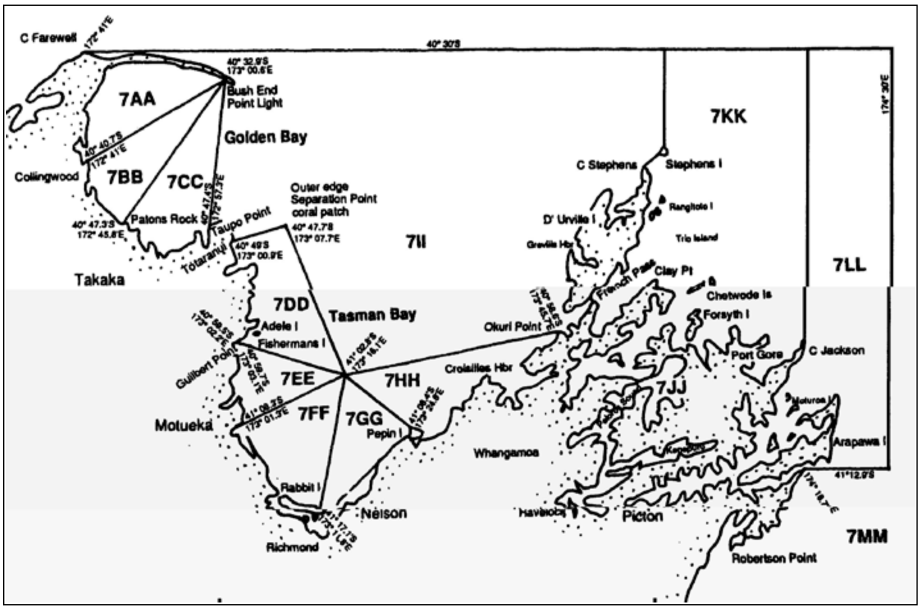
DREDGE OYSTERS (OYS7) – Nelson/Marlborough

(*Ostrea chilensis*)



1. FISHERY SUMMARY

OYS 7 comprises the Nelson/Marlborough area from Cape Farewell in the north, throughout Golden Bay, Tasman Bay and the Marlborough Sounds, to West Head, Tory Channel in the south (see area map). OYS 7 is considered a separate fishery from OYS 7C (West Head, Tory Channel to Clarence Point) on the basis of differences in habitat and environmental parameters. OYS 7 was introduced into the QMS on 1 October 1996 with a TACC of 505 t. There is no TAC for this fishery (Table 1).

Table 1: Total Allowable Commercial Catch (TACC, t) declared for OYS 7 since introduction into the QMS in 1996.

Year	TAC	Customary	Recreational	Other Mortality	TACC
1996 – present	–	–	–	–	505

1.1 Commercial fishery

Dredge oysters in the Nelson/Marlborough area were first exploited in 1845. From 1963 to 1981 oysters were landed mainly as bycatch, firstly by the green-lipped mussel (*Perna canaliculus*) dredge fishery and subsequently by the scallop (*Pecten novaezelandiae*) dredge fishery (Drummond 1994a). In 1981 the Challenger scallop fishery was closed and commercial dredge operators started targeting oysters.

Shellfish dredging in Tasman Bay, Golden Bay, and the Marlborough Sounds became a multi-species fishery with oysters, scallops, and green-lipped mussels caught together. Until 1999, oyster and scallop seasons did not overlap and this prevented both species being landed together. Since then a relaxation of seasonal restrictions has meant there is now potential for the seasons to overlap.

In 1983, fishery regulations and effort restrictions were updated (Drummond 1994a). Fishery regulations included a minimum size (legal sized oysters could not pass through a 58 mm internal diameter ring), an open season (1 March to 31 August), area closures, and a prohibition on dredging at night. A 500 t (greenweight) catch restriction was implemented for Tasman Bay in 1986 and extended to include Golden Bay in 1987 (Drummond 1987). The 500 t catch restriction was revoked in 1996 and a TACC of 505t was set when oysters were brought in to the Quota Management System. The commercial oyster season was extended to 12 months and since 1 October 1999 catch has been reported by fishing year which runs from 1 October to 30 September. Fishers had been required to land all legal sized oysters, but approval was given to return oysters to the sea as long as they are likely to survive.

From 1980, catches of oysters, from Tasman Bay, Golden Bay, and the Marlborough Sounds were recorded on weekly dredge forms for each Shellfish Management Area (Table 2). In 1992, the Nelson-Marlborough dredge oyster statistical areas were established (see area map) by adopting the same reporting areas used by the scallop fishery. Prior to 1999 when the oyster season ran from 1 March to 31 August catch data was presented by calendar year (Table 3). Thereafter reported landings are given by fishing year, 1 October to 30 September. Data from 1989 to 1999 show oysters landed out of season and these data have been included in the summaries shown in Tables 2–4. Most of the catch in OYS 7 comes from Tasman Bay, with small landings from Golden Bay (Table 4).

In recent years, the industry has voluntarily restricted catch levels according to the biomass and distribution of the population estimated in the annual biomass survey, and the economics of catch per unit effort during the season. Landings are reported in greenweight and have been negligible since 2008–09.

Table 2: Reported and adjusted catch (t, greenweight) in the Challenger fishery, 1963–1988 (from Annala et al 2001). Sourced from MAF Marine Dept. Report on Fisheries between 1963 and 1980, the FSU database between 1981 and 1986, and Quota Monitoring System (QMS) in 1987 and 1988. Catches adjusted to account for non-reporting of factory reject oysters (16.2% by number) and use of an incorrect conversion factor.

Year	Reported catch	Adjusted catch	Year	Reported catch	Adjusted catch	Year	Reported catch	Adjusted catch
1963	3	3	1972	65	82	1981	389	492
1964	6	8	1973	190	240	1982	432	546
1965	0	0	1974	78	99	1983	593	750
1966	24	33	1975	136	172	1984	259	328
1967	44	57	1976	392	496	1985	405	512
1968	69	87	1977	212	268	1986	527	667
1969	22	28	1978	40	51	1987	380	–
1970	74	94	1979	83	105	1988	256	–
1971	34	43	1980	160	202			

Table 3: Reported landings (t, greenweight) in the Challenger fishery for the 1989–1999 oyster seasons (1 March to 31 August). Data extracted from MPI database, originally reported on Quota Monitoring Returns (QMR).

Year	QMR	Year	QMR
1989	538	1995	694
1990	206	1996	572
1991	187	1997	447
1992	290	1998	436
1993	476	1999	335
1994	584		

Table 4: Reported landings (t, greenweight) in the Challenger fishery after October 1999 when the fishing season was extended to a full year (1 October–30 September). Data extracted from MPI database, originally reported on Quota Monitoring Returns (QMR) for 1999–00 and 2000–01 and on Monthly Harvest Returns (MHR) thereafter.

Fishing year	QMR	MHR
1999–00	132	–
2000–01	25	–
2001–02	–	1.4
2002–03	–	183.0
2003–04	–	97.5
2004–05	–	146.8
2005–06	–	170.9
2006–07	–	132.1
2007–08	–	21.0
2008–09	–	< 0.1
2009–10	–	0.0
2010–11	–	5.9
2011–12	–	0.0
2012–13	–	0.0
2013-14	–	1.37

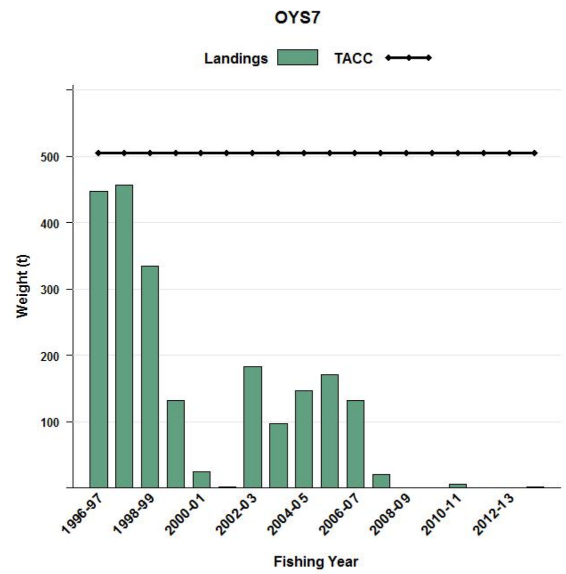


Figure 1: Landings of oysters from OYS7 (t, green weight). Oyster season 1 March to 31 August for years 1963 to 1999. No seasonal restrictions from the 1999−2000 fishing year (October stock) shown as year 2000 onwards. Adjusted catch 1963−1986; reported catch 1987−1988; Quota Monitoring Returns (QMR) 1989–2001; and Monthly Harvest Returns (MHR) 2002 to present. TACC from 1996.

1.2 Recreational fishery

The recreational daily bag limit for oysters in the Challenger fishery area is 50 per person. Oysters that cannot pass through a 58 mm internal diameter solid ring are deemed legal size. The recreational season for dredge oysters in the Challenger area is all year round. Oysters must be landed in their shells. Recreational fishers take oysters in Tasman and Golden Bays by diving and dredging. A survey of the recreational catch of scallops and dredge oysters in Golden and Tasman Bay conducted in 2003–04 estimated that 5800 (95% CI 3800–8400) oysters were taken recreationally during that season (Cole et al 2006).

1.3 Customary fisheries

There are no data available on the customary catch.

1.4 Illegal catch

There is no quantitative information on the level of illegal catch.

1.5 Other sources of mortality

The Nelson/Marlborough area occasionally experiences blooms of diatoms, which result in an anaerobic slime that smothers benthic fauna (Bradford 1998, Mackenzie et al1983, Tunbridge 1962). The level of dredge oyster mortality from this source is unknown.

Bonamia exitiosa is a haemocritic, haplosporid parasite (infects mainly haemocytes or blood cells) of flat oysters and is known to infect *Ostrea chilensis* in New Zealand and Chile and various other species of *Ostrea* in other countries. *Bonamia* has caused catastrophic mortality in the Foveaux Strait oyster fishery and is endemic in oysters in the OSY 7 area (Hine *pers. comm.*). *Apicomplexan* has also been identified in poor condition oysters dredged from Tasman Bay. *Apicomplexan* is a group of obligate pathogens that are thought to predispose oysters to infection by *Bonamia*. The level of mortality caused by disease agents in OYS 7 is unknown.

Drummond & Bull (1993) reported some incidental mortality from dredging. No other data are available on incidental mortality of oysters in OYS 7 caused by fishing. A study on incidental mortality of oysters was completed by Cranfield et al 1997 however, this work was specific to the Foveaux Strait oyster fishery so may or may not have relevance to OYS 7.

2. BIOLOGY

The biology of *O. chilensis* was summarised by Handley & Michael (2001), and further biological data was presented in Brown et al (2008). Most of the parameters required for management purposes are based on the Foveaux Strait fishery described by Cranfield & Allen (1979).

Oysters in OYS 7 (Tasman Bay) tend to be uniformly distributed at a lower density on muddy habitat. Environmental factors such as hydrodynamics, seasonal water temperature and riverine inputs differ substantially among the OYS 7, OYS 7C and OYU 5 areas and these factors will influence the biological characteristics of these oyster populations.

Oyster stocks in the OYS 7 area are generally low and seasonally variable, suggesting high variability in recruitment (Osborne 1999). Challenger oysters are reported to spawn at temperatures above 12°C (Brown et al2008). Compared to the Foveaux Strait fishery, in Tasman and Golden Bay significantly smaller and less developed larvae have been collected in the plankton, implying that Challenger oysters appear to release their larvae into the plankton for longer periods (Cranfield & Michael 1989). Cranfield & Michael (1989) estimated that the larvae could disperse 20 km in 5–12 days, but a more recent study concluded that although a small proportion may travel several kilometres, the majority of the larvae disperse no further than a few hundred meters from the parent population (Brown et al2008). Tunbridge (1962), Stead (1976) and Drummond (1994a) all pointed out that the productivity of the fishery is likely to be limited by a paucity of settlement substrate in the soft sediment habitat of Tasman and Golden Bay. A study by Brown et al (2008) demonstrated increased oyster productivity where shell material was placed on the seabed as a settlement substrate for oyster larvae, and oyster productivity was higher in areas enhanced with brood stock.

The variability in shell shapes and high variability in growth rate between individuals, between areas within the OYS 7 fishery, and between years require careful consideration in describing growth. Assuming the minimum legal size of oysters could range in diameter (1/2 length + height) from 58 mm to 65 mm, data from Drummond (1994b) indicated that Tasman Bay oysters could grow to legal size in two to three years. Modelling of limited data from Tasman Bay in Brown et al (2008) indicated that 77% of three year old oysters and 82% of 4 year old oysters would attain lengths greater than the minimum legal size of 58 mm length at the start of the fishing season. Osborne (1999) used results from a MAF Fisheries study conducted between 1990 and 1994 to construct a von Bertalanffy equation describing oyster growth in the OYS 7 fishery. Estimated biological parameters including instantaneous natural mortality (M) from Drummond (1993, 1994b) and growth parameters for von Bertalanffy equations from Osborne (1999) and from Brown et al (2008) are given in Table 5. Mortality estimates by Drummond (1994b) and growth parameters in Osborne (1999) were derived from a tagging study conducted in Tasman Bay between 1990 and 1992 (Drummond 1993). Von Bertalanffy growth parameters in Brown et al (2008) were estimated based on a limited data set from enhanced habitat experiments, and describe growth of young oysters. Estimates of M based on experimental data from Foveaux and Tasman Bay ranged from 0.042 (Dunn et al 1998b) to 0.92 (Drummond et al1994b). However, after some discussion the Shellfish Working Group (SFWG) concluded that those figures were not realistic, and that M was likely to lie between 0.1 and 0.3.

Table 5: Estimated biological parameters for oysters in OYS 7. Mortality (M) estimates from Drummond (1993, 1994b). Parameters derived for von Bertalanffy equations describing growth of oysters (diameter in millimetres) in Tasman Bay from Osborne (1999) and Brown et al (2008).

Parameter	Estimate	Uncertainty		Source
	mean	SD	95%CI	
M	0.92	-	0.48	Drummond (1994)
M	0.2	-	-	Drummond (1993)
k	0.99	0.16	-	Brown et al (2008)
k	0.597	-	-	Osborne (1999)
L_{inf}	67.52	3.91	-	Brown et al (2008)
L_{inf}	85.43	-	-	Osborne (1999)
t_0	0.11	0.02	-	Brown et al (2008)

3. STOCKS AND AREAS

Patches of commercial densities of oysters within the OYS 7 fishery are largely restricted to Tasman Bay. The oyster population in OYS 7 is likely to be biologically isolated from populations in Foveaux Strait (OYU 5) and at the Chatham Islands (OYS 4) on the basis of geographical distance. The populations in OYS 7 and OYS 7C could also be biologically distinct due to their geographical separation, potentially causing limited dispersal of larvae between the two areas.

4. STOCK ASSESSMENT

Scallop and oyster surveys that estimated oyster densities since 1959 are shown in Table 6. Surveys between 1959 and 1995 used different dredges, survey designs and methods and are not comparable. Surveys since 1996 have estimated oyster biomass concurrently with scallops from one or two-phase, stratified random designs, but strata have not been optimised for oysters. Although surveys of oyster biomass are comparable from 1996, the high CV limit the usefulness of these survey data to establish meaningful trends in the fishery.

Table 6: Surveys of oysters in Tasman (TB) and Golden Bays (GB) from 1959 to present (no survey in 2013 or 2014). Surveys either targeted oysters (Target species) to estimate oyster density and distribution or sampled oysters concurrently in surveys targeting scallops (Scallops), but without optimising survey designs for oysters. [Continued on next page]

Survey	Location	Target species	Survey design	Reference
1959-1960	TB	Scallops	Targeted	Choat (1960)
1961	TB, GB	Oysters	Grid and targeted	Tunbridge (1962)
1969-75	TB, GB	Oysters	Targeted	Stead (1976)
1984–86	TB, GB	Oysters	Grid	Drummond (unpub. Report)
1996	TB, GB	Scallops	Two-phase stratified random	Cranfield et al(1996)
1997	TB, GB	Scallops	Two-phase stratified random	Cranfield et al(1997)
1998	TB, GB	Scallops	Two-phase stratified random	Osborne (1998)
1999	TB, GB	Scallops	Two-phase stratified random	Breen & Kendrick (1999)
2000	TB, GB	Scallops	Two-phase stratified random	Breen (2000)

Table 6 [Continued]:

2001	TB, GB	Scallops	Two-phase stratified random	Horn (2001)
2002	TB, GB	Scallops	Two-phase stratified random	Horn (2002)
2003	TB, GB	Scallops	Two-phase stratified random	Horn (2003)
2004	TB, GB	Scallops	Two-phase stratified random	Horn (2004)
2005	TB, GB	Scallops	Two-phase stratified random	Horn (2005)
2006	TB, GB	Scallops	Two-phase stratified random	Horn (2006)
2007	TB, GB	Scallops	Two-phase stratified random	Brown (2007)
2008	TB, GB	Scallops	Two-phase stratified random	Brown (2008)
2009	TB	Scallops	Single-phase stratified random	Williams et al (2009)
2010	TB	Oysters	Grid and targeted	Michael (2010)
2010	TB	Scallops	Single-phase stratified random	Williams et al (2010)
2011	TB	Scallops	Single-phase stratified random	Williams & Michael (2011)
2012	TB	Oysters	Single-phase stratified random	Williams & Bian (2012)

4.1 Estimates of fishery parameters and abundance

Growth and mortality are poorly estimated for oysters from OYS 7. Growth estimates from Drummond's (1994b) mark recapture data and estimates from Osborne (1999) give von Bertalanffy parameter estimates of 79.6 and 85.4 for L_∞, and 2.03 and 0.60 for *k* respectively. Drummond (1994b) estimated *M*=0.92 (considered unlikely by the Shellfish Working Group) and *M*=0.17. The Shellfish Working Group considers *M* is most likely to lie between 0.1 and 0.3.

Estimates of the numbers of recruits (oysters unable to pass through a 58 mm ring) and pre-recruits (less than 58 mm) from Tasman Bay and Golden Bay since 1998 are shown in Table 7.

Table 7: Relative estimates (millions) uncorrected for dredge efficiency of recruited and pre-recruit oysters in Tasman and Golden Bays from surveys (1998 to present). No survey in 2013.

	Tasman Bay				Golden Bay			
Year	Recruits	CV	Pre-recruits	CV	Recruits	CV	Pre-recruits	CV
1998	28.7	7.3	30.4	10.1	1.4	13.3	0.4	18.7
1999	24.7	8.6	39.6	13.6	1.9	23.7	1.2	24.8
2000	21.8	8.9	33.5	9.9	1	14.3	0.5	17.6
2001	17.8	9	23.1	9.1	0.4	20.1	0.4	28.1
2002	15.9	10.6	24.5	11.2	0.4	21.4	0.3	27.1
2003	12.4	9.7	34.3	13.4	0.4	27.1	0.4	27.6
2004	10.9	6.7	16.1	8.1	0.4	25.4	0.2	18.8
2005	11.3	10.2	25.2	17.7	0.3	38.8	0.3	41.6
2006	10.7	8.6	18.5	14.8	0.1	29.1	0.04	46.6
2007	14.8	14.3	6.5	19.4	0.1	32	0.04	32.3
2008	9.6	20.5	8.9	25.2	0.04	47.1	0.01	39.5
2009	14.7	20	18.8	36	–•	–•	–•	–•
2010	14	26	9	54	–•	–•	–•	–•
2011	8	48	19	61	–•	–•	–•	–•
2012	6.8	22	21	21	–•	–•	–•	–•
2013	–•	–•	–•	–•	–•	–•	–•	–•
2014	–•	–•	–•	–•	–•	–•	–•	–•

• Golden Bay has not been surveyed since 2009 because this area has not been targeted for commercial fishing
• Tasman Bay has not been surveyed since 2012

4.2 Biomass estimates

Estimates of the recruited biomass (≥ 58 mm) of oysters in both Tasman Bay and Golden Bay (made from surveys of oysters and scallops combined) show a general decline from 1998 to 2012 (Table 8).

Table 8: Estimates of relative biomass (t) of recruited oysters from Tasman and Golden Bays (1998 to present).

	Tasman Bay		Golden Bay		OYS 7			
Year	Biomass (t)	CV	Biomass (t)	CV	Total Biomass (t)	References	Total catch (t)	Exploitation rate (catch/biomass)
1998	2 214	7.3	113	11.5	2 327	Osborne (1999)	436	0.19
1999	2 012	8.1	151	22.1	2 163	Breen & Kendrick (1999)	335	0.15
2000	1 810	8.8	86	15.4	1 895	Breen (2000)	132	0.07
2001	1 353	9.7	25	20.3	1 378	Horn (2001)	25	0.02
2002	1 134	10	28	21.9	1 162	Horn (2002)	1	0.00
2003	1 019	10	23	26.6	1 042	Horn (2003)	183	0.18
2004	894	6.9	28	22.4	921	Horn (2004)	98	0.11
2005	932	11.3	24	30.8	956	Horn (2005)	147	0.15
2006	817	26.1	10	8.0	827	Horn (2006)	171	0.21
2007	1 275	13.5	10	31.4	1 285	Brown (2007)	132	0.10
2008	744	20.8	3	52.0	747	Tuck & Brown (2008)	21	0.03
2009	1 208	19	–•	–•	1 208	Williams et al (2009)	0	0.00
2010	1 259	27	–•	–•	1 259	Williams et al (2010)	0	0.00
2011	622	42	–•	–•	622	Williams & Michael (2011)	6	0.01
2012	567	23	–•	–•	567	Williams & Bian (2012)	0	0.00
2013	–•	–•	–•	–•				
2014	–•	–•	–•	–•				

• Golden Bay has not been surveyed since 2009 because this area has low densities of oysters and is not targeted for commercial fishing.

• Tasman Bay has not been surveyed since 2012

4.3 Yield estimates and projections

Drummond (1994) estimated a MCY of 300 tonnes using method 4 in the Guide to Biological Reference Points (see Introduction to this Plenary), but Osborne concluded that catch levels in OYS 7 appear to be driven by the economics of the catch rates (Osborne 1999). She used equation 2 of the Guide to Biological Reference Points to estimate MCY (Table 9):

$$MCY = 0.5F_{0.1}B_{AV}$$

Where B_{AV} = 1191 tonnes (from relative biomass estimates from CSEC surveys 1998 to 2012). The natural mortality (M) values used in the yield calculations were restricted to the range 0.1 to 0.3. This was reduced from the previous range of 0.042 to 0.9 because the extreme values were considered, by the SFWG, to be very unlikely. These estimates are not corrected for dredge efficiency (assumed to be 100%) and are likely to be conservative.

Table 9: Estimates of $F_{0.1}$ and MCY for M 0.1-0.3. MCY 1 was estimated using $F_{0.1}$ 1 from Osborne (1999), MCY 2 from $F_{0.1}$ 2 estimated from von Bertalanffy growth parameters estimated by Osborne (1999), growth data from Drummond (1994b) and Foveaux Strait oyster size weight data, and MCY 3 from $F_{0.1}$ 3 estimated von Bertalanffy growth parameters from GROTAG using the same growth and size weight data.

M	$F_{0.1}$ 1	MCY 1	$F_{0.1}$ 2	MCY 2	$F_{0.1}$ 3	MCY 3
0.1	0.29	173	0.17	101	0.22	131
0.2	–		–		0.38	226
0.3	0.45	268	0.38	226	0.55	327

CAY was estimated for OYS 7 using Method 1 of the Guide to Biological Reference Points assuming dredge oysters are landed over the year, and using $F_{0.1}$ estimated by three different methods, a range of assumed M (0.1 to 0.3), and the 2012 estimate of recruited biomass (567 t; Table 10).

$$CAY = \frac{F_{ref}}{F_{ref} + M}\left(1 - e^{-(F_{ref}+M)}\right)B_{beg}$$

Table 10: Estimates of CAY for OYS7 using different estimates of $F_{0.1}$ over a range of assumed values for *M* (0.1–0.3), and an estimate of recruited biomass in 2012 (567 t). CAY 1 was estimated using $F_{0.1}$ 1 from Osborne (1999), CAY 2 from $F_{0.1}$ 2 estimated from von Bertalanffy growth parameters estimated by Osborne (1999) using growth data (Drummond, 1994b) and Foveaux Strait oyster size weight data, CAY 3 from $F_{0.1}$ 3 estimated von Bertalanffy growth parameters from GROTAG using the same growth and size weight data.

M	$F_{0.1}$ 1	CAY 1	$F_{0.1}$ 2	CAY 2	$F_{0.1}$ 3	CAY 3
0.1	0.29	136	0.17	84	0.22	107
0.2	–		–		0.38	163
0.3	0.45	180	0.38	156	0.55	210

The risk to the stock associated with harvesting at the estimated CAYs cannot be determined.

4.4 Other yield estimates and stock assessment results

There are no other yield estimates and stock assessments

4.5 Other factors

The challenger dredge oyster fishery is thought to be recruitment-limited. Drummond (1994a) Stead (1976) and Tunbridge (1962) attributed the lack of dense aggregations of oysters in the Challenger fishery (compared to Foveaux Strait) to a scarcity of suitable settlement surface. Challenger Oyster Enhancement Company (COEC) initiated habitat enhancement trials in 2008, aimed at boosting productivity of the fishery (Brown et al 2008), but these areas have been bottom trawled and there has been no monitoring to determine the effectiveness of the enhancement.

5. ENVIRONMENTAL AND ECOSYSTEM CONSIDERATIONS

This section was reviewed by the Aquatic Environment Working Group for inclusion in the Fishery Assessment Plenary November 2014. A broader summary of information on a range of issues related to the environmental effects of fishing and aspects of the marine environment and biodiversity of relevance to fish and fisheries is available in the Aquatic Environment & Biodiversity Annual Review (Ministry for Primary Industries 2013a).

5.1 Role in the ecosystem

Dredge oysters (*Ostrea chilensis*) are benthic, epifaunal, sessile bivalve molluscs that have a relatively limited pelagic larval dispersal phase. They are patchily distributed around the New Zealand coast on a variety of substrates (biogenic reef, gravel, sand, mud) in intertidal to subtidal inshore waters, commonly in depths of up to 60 m or more. Commercially exploited beds of oysters occur in Foveaux Strait (OYU 5), Tasman Bay (OYS 7), and Cloudy and Clifford Bays (OYS 7C). Beds at the Chatham Islands (OYS 4) have potential for commercial exploitation. Oysters play important roles in the ecosystem that include influencing water quality by filtering phytoplankton and other suspended particles from the seawater, linking primary production with higher trophic levels, and acting as ecosystem engineers by stabilising sediments and providing structural habitat (biogenic reef) for other taxa (e.g., algae, ascidians, bryozoans, sponges, echinoderms, worms, molluscs, crustaceans, fish).

5.1.1 Trophic interactions

Oysters are active suspension feeders, consuming phytoplankton suspended in the water column. Their diet is the same as or similar to that of many other suspension feeding taxa, including other bivalves such as scallops, clams, and mussels. Oysters are probably prey for a wide range of invertebrate and fish predators, but published records of known or suspected predators are limited. Reported invertebrate predators of *O. chilensis* include brittlestars (*Ophiopsammus maculata*) (Stead 1971), starfish (*Coscinasterias calamaria* and *Astrostole scabra*) (Cranfield 1979) and flatworms (*Enterogonia orbicularis*) (Handley 2002); suspected invertebrate predators include octopus (*Pinnoctopus cordiformis*) and shell boring gastropods (*Poirieria zelandica*, *Xymeme* *ambiguous*, and *Xymenella pusillis*) (Brown 2012). Predators of oysters probably change with oyster size. Most mortality of oyster spat (small juveniles) during their first winter appears to result from predation by polychaetes, crabs, and gastropods (Ministry for Primary Industries 2013b).

5.2 Incidental catch (fish and invertebrates)

A range of non-target fish and invertebrate species are caught and discarded by dredge fisheries for *O. chilensis*. No data are available on the level or effect of this incidental catch (bycatch) and discarding by the fisheries. Invertebrate bycatch data are available from dredge surveys of the oyster stocks, and the bycatch of the fisheries is likely to be similar to that of the survey tows conducted in areas that support commercial fishing. Fish bycatch data are generally not recorded on surveys, presumably because fish constitute a small fraction of the total bycatch.

In OYU 5 (Foveaux Strait), Cranfield et al. (1999) summarised the results of Fleming (1952) who sampled the macrofaunal bycatch of oyster fishing in a 'near virgin' area of the fishery in 1950; the bycatch was dominated by the frame-building bryozoan *Cinctipora elegans* (and oysters *O. chilensis*) and included a diverse range of other epifaunal organisms. More recently, presence-absence data on the bycatch of oyster dredging have been recorded during surveys and in fishers' logbooks (Michael 2007). In a specific study of the benthic macrofauna bycatch of the 2001 oyster dredge survey in Foveaux Strait, Rowden et al. (2007) identified at least 190 putative species representing 82 families and 12 phyla; 'Commercial' survey strata were principally characterised by the families Balanidae (barnacles), Mytilidae (mussels), Ophiodermatidae (brittle stars), Ostreidae (oysters), and Pyuridae (tunicates). For the 2007 survey of OYU 5, Michael (2007) listed the percentage occurrence of sessile and motile species caught as bycatch in the survey dredge tows. The five most commonly caught sessile species (excluding oysters) were hairy mussels *Modiolus areolatus* (80% occurrence), barnacles *Balanus* sp. (61%), kina *Evechinus chloroticus* (61%), nesting mussels *Modiolarca impacta* (53%), and ascidians *Pyura pulla* (51%). The five most commonly occurring motile bycatch species were brittlestars *Ophiopsammus maculata* (90% occurrence), circular saw shells (gastropods) *Astraea heliotropium* (80%), hermit crabs *Pagurus novizelandiae* (80%), eight armed starfish *Coscinasterias muricata* (63%), and brown dipple starfish *Pentagonaster pulchellus* (54%). Common bycatch species of oyster dredge surveys in Foveaux Strait were reported by Michael (2007) and are listed below in Table 11.

Table 11: Invertebrate species commonly caught as bycatch in dredge surveys of oysters (*O. chilensis*) in Foveaux Strait. Sourced from Michael (2007). [Continued on next page]

Type	Species
Infaunal bivalves	*Glycymeris modesta* (small dog cockle), *Tawera spissa* (morning star shell), *Tucetona laticostata* (large dog cockle), *Pseudoxyperas elongata* ('tuatua'), *Venericardia purpurata* (purple cockle)
Epifaunal bivalves	*Modioilus areolatus* hairy mussel), *Modiolarca impacta* (nesting mussel), *Aulacomya atra maoriana* (ribbed mussel), *Barbatia novaezelandiae* (ark shell), *Pecten novaezelandiae* (scallop), *Chlamys zelandiae* (lions paw scallop), *Neothyris lenticularis* (large lantern shell), *N. compressa* (compressed lantern shell)
Sponges	*Chondropsis* topsentii (cream sponge), *Crella incrustans* (red-orange sponge), *Dactylia palmata* (finger sponge)
Ascidians	*Pyura pachydermatina* (kaeo), *P. pulla*
Algae	Red algae spp.
Bryozoans	*Celleporaria agglutinans* (hard/plate coral), *Cinctipora elegans (reef-building bryozoan)*, *Horera foliacea* (lace coral), *Hippomenella vellicata* (paper coral), *Tetrocycloecia neozelanica* (staghorn coral), *Orthoscuticella fusiformis* (soft orange bryozoan)
Barnacles and chitons	*Balanus decorus* (large pink barnacle), *Cryptochonchus porosus* (butterfly chiton), *Eudoxochiton nobilis* (noble chiton), *Rhyssoplax canaliculata* (pink chiton)
Starfish, brittlestars, and holothurians	*Coscinasterias muricata* (eight armed starfish), *Pentagonaster pulchellus* (brown dipple starfish), *Ophiosammus maculata* (snaketail brittlestar), *Australostichopus mollis* (sea cucumber)

Table 11 [Continued]:

Crabs	*Pagurus novaezelandiae* (hermit crab), *Eurynolambrus australis* (triangle crab), *Metacarcinus novaezelandiae* (cancer crab), *Nectocarcinus* sp. (red crab)
Urchins	*Evechinus chloroticus* (kina), *Apatopygus recens* (heart urchin), *Goniocidaris umbraculum* (coarse-spined urchin), *Pseudechinus novaezelandiae* (green urchin), *P. huttoni* (white urchin), *P. albocinctus* (red urchin)
Gastropods	*Astraea heliotropium* (circular saw shell), *Alcithoe arabica* (volute), *Argobuccinum pustulosum tumidum, Turbo granosus, Cabestana spengleri, Charonia lampras*
Octopuses	*Pinnoctopus cordiformis* (common octopus), *Octopus huttoni* (small octopus)

In OYS 7 (Tasman/Golden Bays), data on the bycatch of the 1994–2014 dredge surveys have been collected but not analysed, except for preliminary estimation of the 1998–2013 bycatch trajectories (Williams et al. 2014b). The surveys record the bycatch of other target species of scallops (*Pecten novaezelandiae*) and green-lipped mussels (*Perna canaliculus*), and various other non-target bycatch in nine categories (Williams et al. 2014b). Observation of the 2014 survey sampling identified a problem with the way these categorical bycatch data have been recorded which limits their utility (Williams et al. 2014a).

In OYS 7C, a dredge survey of oysters in Cloudy and Clifford Bays was conducted in 2006, and the survey skipper recorded qualitative comments on the bycatch of each tow, which included ‘coral’, ‘sticks and seaweed’, shells, volutes, ‘red weed’, horse mussels, shell with worm, small crabs, mussels, and scallop (Brown & Horn 2006).

In OYS 4 (Chatham Islands), data on the bycatch of a 2013 dredge survey of oysters off the north coast of Chatham Island were recorded (as estimated volumes of different bycatch categories) but not analysed (Williams et al. 2013).

5.3 Incidental catch (seabirds, mammals, and protected fish)

There is no known bycatch of seabirds, mammals or protected fish species from *O. chilensis* oyster fisheries.

5.4 Benthic interactions

There are a variety of benthic habitats in the different oyster fisheries areas, which generally occur either on coarse substrates usually found in areas of high natural disturbance (Foveaux Strait, Cloudy/Clifford Bays and the Chatham Islands) or on fine substrates typical of sheltered areas (Tasman Bay). Benthic habitats within the Foveaux Strait oyster fishery area were classified by Michael (2007) and comprise a variety of sand/gravel/shell flats and waves, rocky patch reef, and biogenic areas. Cranfield et al. (1999) referred to the latter as epifaunal reefs that he defined as ”tidally-oriented, linear aggregations of patch reefs formed by the bryozoan *Cinctipora elegans*, cemented by encrusting bryozoans, ascidians, sponges and polychaetes”. Cranfield et al.’s papers (Cranfield et al. 1999, Cranfield et al. 2001, Cranfield et al. 2003) suggested that epifaunal reefs are oyster habitat, but Michael’s reports (Michael 2007, 2010) state that commercial fishing for oysters is mainly based on sand, gravel, and shell habitats with little epifauna. In Foveaux Strait, commercial oyster dredging occurs within an area of about 1000 km^2 (although only a portion of this is dredged each year), which is about one-third of the overall OYU 5 stock area (Michael 2010). Habitats within the Cloudy/Clifford Bays and the Chatham Islands fisheries areas have not been defined. The benthic habitat within the Tasman Bay oyster fishery area is predominately mud, although to some extent this may have been affected by land-based sedimentation into the bay and homogenisation of the substrate by dredging and trawling (Brown 2012).

It is well known that fishing with mobile bottom contact gears such as dredges has impacts on benthic populations, communities, and their habitats (e.g., see Kaiser et al. 2006, Rice 2006). The effects are not uniform, but depend on at least: “the specific features of the seafloor habitats, including the natural disturbance regime; the species present; the type of gear used, the methods and timing of deployment of the gear, and the frequency with which a site is impacted by specific gears; and the history of human activities, especially past fishing, in the area of concern”

(Department of Fisheries and Oceans 2006). In New Zealand, the effects of oyster dredging on the benthos have been studied in Foveaux Strait (OYU 5) (Cranfield et al. 1999, Cranfield et al. 2001, Cranfield et al. 2003, Michael 2007) and Tasman/Golden Bays (OYS 7) (Tuck et al. 2011). The results of these studies are summarised in the Aquatic Environment & Biodiversity Annual Review (Ministry for Primary Industries 2013a), and are consistent with the global literature: generally, with increasing fishing intensity there are decreases in the density and diversity of benthic communities and, especially, the density of emergent epifauna that provide structured habitat for other fauna.

The effects of dredging (Ministry for Primary Industries 2013a) may be more severe in sheltered areas (e.g., Tasman Bay) than in exposed areas (e.g., Foveaux Strait, Cloudy/Clifford Bays, Chatham Islands). Dredging damages epifauna, and erect, structured habitats, such as biogenic/epifaunal reefs, are the most sensitive to dredging disturbance. Dredging destabilises sediment/shell substrates, suspends sediments and increases water turbidity; the sensitivity of habitats to suspended sediments and their deposition probably varies depending on the prevailing natural flow regime, being greater in muddy sheltered areas than in high flow environments. Habitats disturbed by dredging tend to become simpler, more homogenous areas typically dominated by opportunistic species. Dredging generally results in reduced habitat structure and the loss of long-lived species.

For studies of the effects of oyster dredging in Foveaux Strait, interpretation of the authors differ (Ministry for Primary Industries 2013a): ”Cranfield et al’s papers (Cranfield et al. 1999, Cranfield et al. 2001, Cranfield et al. 2003) concluded that dredging biogenic reefs for their oysters damages their structure, removes epifauna, and exposes associated sediments to resuspension such that, by 1998, none of the original bryozoan reefs remained. Michael (2007) concluded that there are no experimental estimates of the effect of dredging in the strait or on the cumulative effects of fishing or regeneration, that environmental drivers should be included in any assessment, and that the previous conclusions cannot be supported. The authors agree that biogenic bycatch in the fishery has declined over time in regularly-fished areas, that there may have been a reduction in biogenic reefs in the strait since the 1970s, and that simple biogenic reefs appear able to regenerate in areas that are no longer fished (dominated by byssally attached mussels or reef-building bryozoans). There is no consensus that reefs in Foveaux Strait were (or were not) extensive or dominated by the bryozoan *Cinctipora*.”

Some areas of the Foveaux Strait (OYU 5) oyster fishery are also commercially fished (potted) for blue cod (*Parapercis colias*), and Cranfield et al. (2001) presented some evidence to suggest that dredged benthic habitats and blue cod densities regenerated in the absence of oyster dredging. Bottom trawling also occurs within the OYU 5 area, but there is little overlap with the main areas fished for oysters. In OYS 7, other benthic fisheries (e.g. bottom trawl, scallop, green-lipped mussel) occur and probably also interact with oysters and their habitats.

5.5 Other considerations

5.5.1 Spawning disruption

Fishing during spawning may disrupt spawning activity or success. In the Foveaux Strait fishery, the traditional harvesting period (1 March to 31 August) occurs after the main spring and summer peaks in oyster spawning activity (Jeffs & Hickman 2000). Fishing-induced damage to oysters incurred during the period before spawning could interrupt gamete maturation. Oyster fishing also targets high-density beds of oysters, which are disproportionately more important for fertilisation success during spawning.

5.5.2 Habitat of particular significance for fisheries management

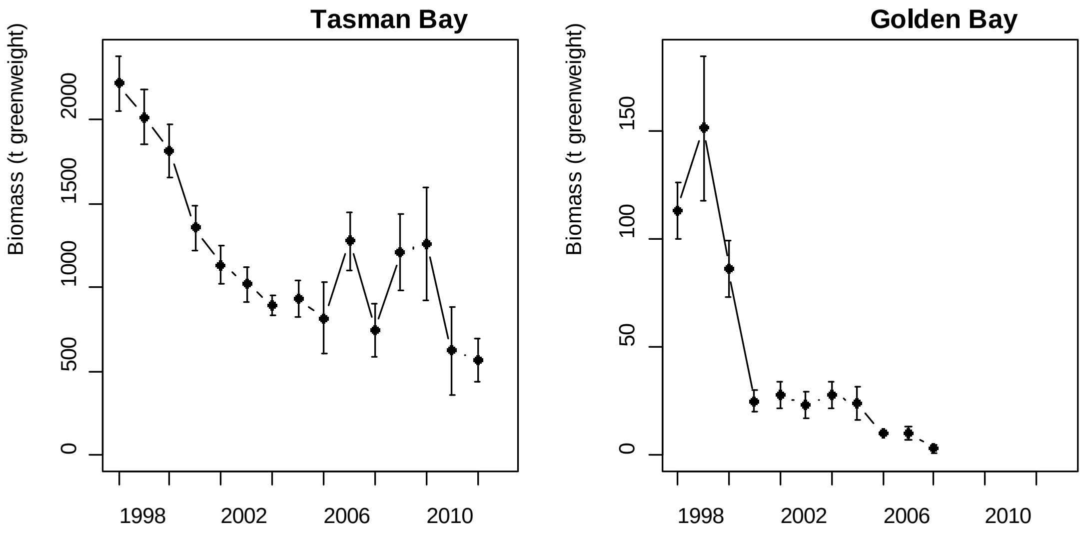
None currently identified.

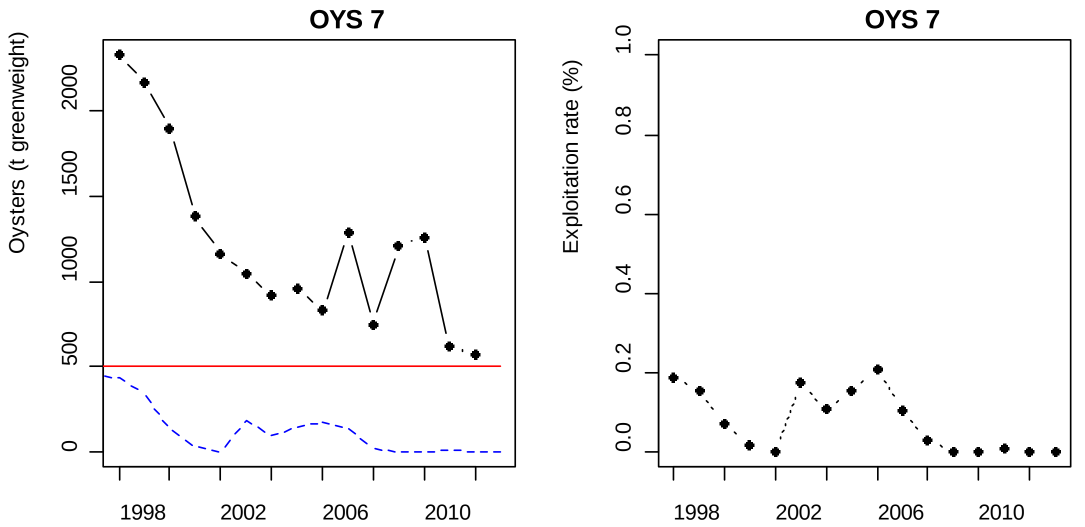
6. STATUS OF THE STOCKS

Stock Structure Assumptions

Current management assumes that the Challenger (OYS 7) oyster fishery is separate from the other oyster fisheries (i.e., Foveaux Strait (OYU 5), Tory Channel, Cloudy and Clifford Bays (OYS 7C), and the Chatham Islands (OYS4)). The stock structure of OYS 7 is assumed to be a single biological stock, although the extent to which the populations in Tasman Bay, Golden Bay, and the Marlborough Sounds are separate reproductively or functionally is not known. Localised patches of oysters in commercial densities within the OYS 7 fishery are largely restricted to Tasman Bay, which is likely to be a single stock.

Stock Status	
Year of Most Recent Assessment	2012
Reference Points	Target: default = 40% B_0, with at least a 50% probability of achieving the target Soft Limit: 20% B_0 Hard Limit: 10% B_0 Overfishing threshold: F_{MSY}
Status in relation to Target	Unlikely (< 40%) to be at or above the target
Status in relation to Limits	Likely (> 60%) to be below Soft Limit Unknown relative to Hard Limit
Status in relation to Overfishing	Unknown
Historical Stock Status Trajectory and Current Status	





Top panel: Estimated (mean and c.v. of) recruited oyster biomass (t greenweight) in Tasman Bay and Golden Bay since 1998. Bottom left: Estimated recruited biomass (solid symbols and black line), TACC (solid red line), and reported landings (dashed blue line) in t greenweight for OYS 7 since 1998. Biomass estimates uncorrected for dredge efficiency; oysters were not surveyed in Golden Bay in 2009–12. Landings data sourced from QMRs for 1998 to 2001, and from MHRs for 2002 to present. Bottom right: Exploitation rate (catch to recruited biomass ratio) since 1998.

Fishery and Stock Trends	
Trend in Biomass or Proxy	The current biomass of the OYS 7 stock is probably at its lowest level since the CSEC survey time series started in 1998. The estimated biomass of recruited oysters in Tasman Bay decreased from over 2000 t in 1998 to less than 1000 t in 2004, apparently fluctuated around that level until 2011, and was an estimated 567 t in 2012. Recruited oyster biomass in Golden Bay has shown a similar downturn, albeit with a much more rapid decline between 1999 and 2001, followed by a period of relative stability at a low level up to 2005, and a gradual decline to a negligible level in 2008. No surveys were undertaken in 2013 or 2014.
Recent trend in Fishing Intensity or Proxy	The exploitation rate on recruited oysters in OYS 7 was about 0.14 for the periods 1998–2000 and 2003–2007, but was negligible in the periods 2001–02 and 2008–14.
Other Abundance Indices	The abundance of pre-recruit oysters has declined at a similar rate to the recruited abundance.
Trends in Other Relevant Indicator or Variables	-
Projections and Prognosis	
Stock Projections or Prognosis	No projections have been conducted.
Probability of Current Catch or TACC causing Biomass to remain below or to decline below Limits	Soft Limit: The TACC is higher than the maximum estimates of CAY and MCY and catches at this level are Very Likely (> 90%) to cause the biomass to remain below the Soft Limit in the near term Hard Limit: Catches at the level of the TACC are also Likely (> 60%) to cause the stock to drop below the Hard Limit in the near term
Probability of Current Catch or TACC causing Overfishing to continue or to commence	Unknown

Assessment Methodology and Evaluation		
Assessment Type	Level 2: Partial Quantitative Stock Assessment - annual random stratified dredge surveys	
Assessment Method	Yields are estimated as a proportion of the survey biomass for a range of assumed values of natural mortality and with assumed dredge efficiency of 100%.	
Assessment Dates	Latest assessment: 2012	Next assessment: unknown
Overall Assessment Quality Rank	1 – High quality	
Main data inputs (rank)	Biomass survey: 2012	1 – High quality
Data not used (rank)	N/A	
Changes to Model Structure and Assumptions	The natural mortality (*M*) values used in the yield calculations were restricted to the range 0.1 to 0.3. This was reduced from the previous range of 0.042 to 0.9 because the extreme values were considered very unlikely.	
Major Sources of Uncertainty	Natural mortality (*M*) and dredge efficiency are poorly known but are integral parameters of the method used to estimate yield.	

Qualifying Comments
The OYS 7 dredge oyster fishery has a lack of dense aggregations of oysters (compared to Foveaux Strait); this is attributed to a scarcity of suitable settlement surface. Recruited biomass is being used as proxy for spawning biomass. Other benthic fisheries (e.g., bottom trawl, scallop, green-lipped mussel) occur in OYS 7 and probably interact with oysters and their habitat. The cause of the declines in these shellfish is unknown, but is probably associated with factors other than simply the magnitude of direct removals by fishing. It may be a combination of natural (e.g., oceanographic) and anthropogenic (e.g., indirect effects of fishing, land-based) factors.

Fishery Interactions
Bycatch data are collected routinely during the annual surveys. Bycatch can include scallops, green-lipped mussels, and a range of other benthic invertebrates. The bycatch of the fishery is likely to be similar to that of the survey.

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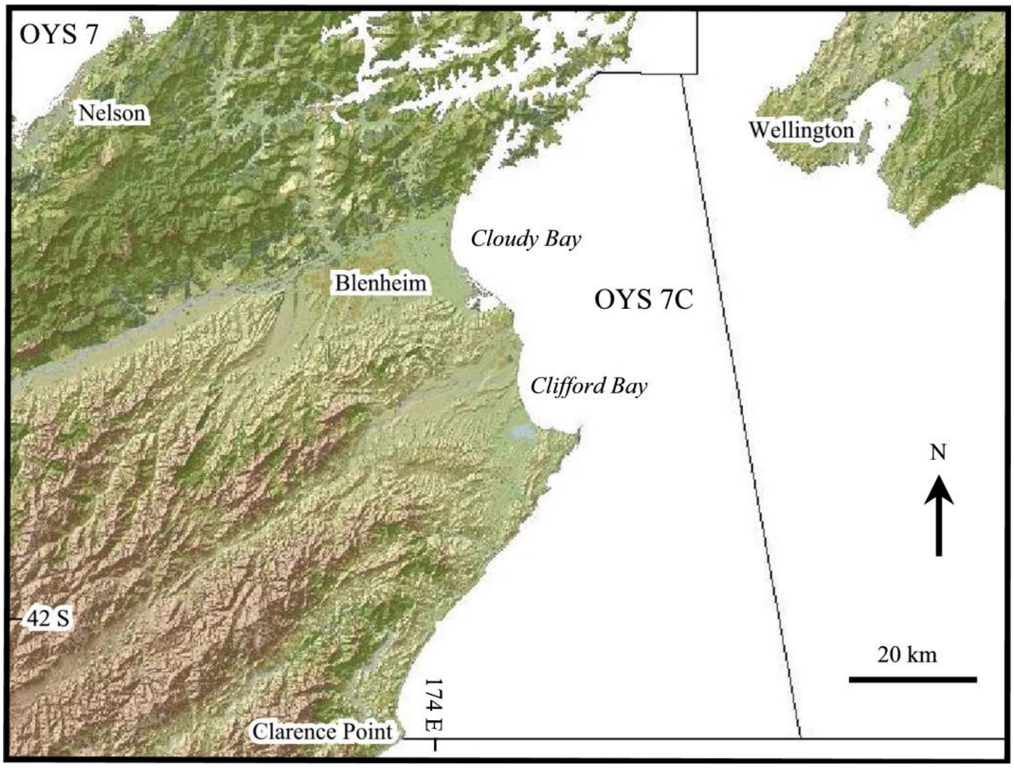
DREDGE OYSTERS (OYS 7C) – Challenger Marlborough

(Ostrea chilensis)



1. FISHERY SUMMARY

OYS 7C encompasses an area from West Head, Tory Channel in the north to Clarence Point in the south including Cloudy Bay and Clifford Bay in the southern part of Cook Strait. OYS7C is considered a separate fishery from OYS 7 (Golden Bay, Tasman Bay, and Marlborough Sounds) on the basis of differences in habitat and environmental parameters.

OYS 7C was introduced into the QMS on 1 October 2005 with a TAC of 5 t and a TACC of 2t. Following a survey in April 2007, the TAC was increased to 50 t with a TACC of 43 t on 1 October 2007. In 2009, with information from CPUE and catch data, the TAC was reviewed again and resulted in a TAC increase to 72t in October 2009 (Table 1). At the time of the review the Shellfish Working Group suggested that raising the TACC by a further 15–20 tonnes was unlikely to be detrimental to the fishery in the short-term, however without improved estimates of mortality, growth, and dredge efficiency, it was difficult to predict the effects the an increased TACC would have on the status of the fishery in the medium to long-term, and that a research strategy for improved assessment was required.

Table 1: Total Allowable Commercial Catch (TACC, t) declared for OYS 7C since introduction into the QMS in 2005.

Fishing year	TAC	TACC	Customary	Recreational	Other
2005–07	5	2	1	1	1
2007-09	50	43	1	1	5
2009 to present	72	62	1	1	8

1.1 Commercial fishery

Commercial landings for OYS 7C are reported in greenweight. The fishing year runs from 1 October to 30 September and fishers can harvest year round (there is no oyster season defined by regulations).

There is historical evidence of limited exploitation of oyster beds within Port Underwood as early as the 1800s (K. Wright pers. comm. in Drummond 1994a). Limited fishing under a special permit took place south of Tory Channel on the east coast of the South Island in 1990 and 1991.

Since 2005, landed catch has been reported via Monthly Harvest Returns (Table 2), though landings were negligible until 2007–08 when the recent commercial operation was initiated. During 2007–08 fishing took place over 30 fishing days from December to February and in 2008–09 fishing took place from January to April. Landings were at about the level of the TACC up to and including 2010–11, but were lower in recent years due to oyster grading and marketing requirements; only 6 t was landed in 2012–13 (Figure 1, Table 2).

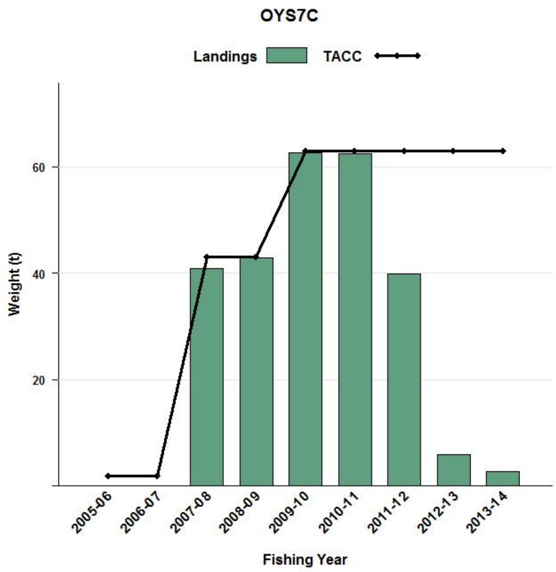


Figure 1: Reported landings (t) and TACC for OYS7C from 2005-06 to present.

Table 2: Reported landings (t) in the OYS 7C fishery since October 2005 (QMS). Reported catch is landed green weight summarised from Monthly Harvest Returns.

Fishing year	TACC	Reported Landings (MHR)
2005–06	2	0.1
2006–07	2	0
2007–08	43	40.9
2008–09	43	38.2
2009–10	62	62.7
2010–11	62	62.5
2011–12	62	39.9
2012–13	62	5.9
2013-14*	62	2.8

*Note that the reported landings in 2013–14 may not include all catch landed at the time of writing this report.

1.2 Recreational fishery

The recreational catch allowance for OYS 7C is 1 tonne. The recreational daily bag limit for oysters in the Challenger fishery area is 50 per person. Oysters that cannot pass through a 58 mm internal diameter solid ring are deemed legal size. The recreational season for dredge oysters in the Challenger area is all year round. Oysters must be landed in their shells. There are no data available on the recreational catch within OYS 7C.

1.3 Customary fisheries

The customary catch allowance for OYS 7C is 1 tonne. There are no data available on the customary catch.

1.4 Illegal catch

There is no quantitative information on the level of illegal catch.

1.5 Other sources of mortality

Bonamia exitiosa is a haemocritic, haplosporid parasite (infects mainly haemocytes or blood cells) of flat oysters and is known to infect *Ostrea chilensis* in New Zealand and Chile and various other species of *Ostrea* in other countries. *Bonamia* has caused catastrophic mortality in the Foveaux Strait oyster fishery and is endemic in oysters in the OSY 7 area (Hine pers. comm.). The level of mortality caused by disease is unknown.

An allowance of 8 t for Other Mortality (including incidental fishing mortality, heightened natural mortality such as disease mortality, and illegal harvest) is included in the TAC.

2. BIOLOGY

There are no biological studies of *O. chilensis* specific to the OYS 7C area. In the absence of area-specific estimates, parameters required for management purposes are based on the Foveaux Strait fishery described by Cranfield & Allen (1979) or the OYS 7 (Tasman Bay) fishery. The biology of oysters in the neighbouring area of OYS 7 (Tasman and Golden Bay) was summarised by Handley & Michael (2001), and further biological data was presented in Brown et al (2008). All this work is summarised below.

Oysters in OYS 7C (Cloudy Bay/Clifford Bay) and OYU 5 (Foveaux) both comprise rather discrete patches of oysters on a predominantly sandy substrate whereas OYS 7 (Tasman Bay) oysters tend to be more uniformly distributed at a lower density on muddy habitat. Environmental factors such as hydrodynamics, seasonal water temperature and riverine inputs differ substantially among the OYS 7, OYS 7C and OYU 5 areas and are likely to influence the biological characteristics of those oyster populations. Oysters in OYS 7C are generally more abundant and occur at higher densities than in OYS 7 (Brown & Horn 2007).

The variability in shell shapes and high variability in growth rate between individuals, between areas within the OYS 7 fishery, and between years require careful consideration in describing growth. Assuming the minimum legal size could range in diameter (1/2 length + height) from 58 mm to 65 mm, data from Drummond (1994b) indicated that Tasman Bay oysters could grow to legal size in two to three years. Modelling of limited data from Tasman Bay in Brown et al (2008) indicated that 77% of three year old oysters and 82% of 4 year old oysters would attain lengths greater than the minimum legal size of 58 mm length at the start of the fishing season. Osborne (1999) used results from a MAF Fisheries study conducted between 1990 and 1994 to construct a von Bertalanffy equation describing oyster growth in the OYS 7 fishery. Estimated biological parameters including instantaneous natural mortality (M) from Drummond (1993, 1994b) and growth parameters for von Bertalanffy equations from Osborne (1999) and from Brown et al (2008) are given in Table 3. Mortality estimates by Drummond (1994b) and growth parameters in Osborne (1999) were derived from a tagging study conducted in Tasman Bay between 1990 and 1992 (Drummond 1993). von Bertalanffy growth parameters in Brown et al (2008) were estimated based on a limited data set from enhanced habitat experiments, and describe growth of young oysters. Estimates of M based on experimental data from Foveaux and Tasman Bay ranged from 0.042 (Dunn et al 1998b) to 0.92 (Drummond et al 1994). However, after some discussion the Shellfish Working Group concluded that those figures were not realistic, and that M was more likely to lie between 0.1 and 0.3.

Table 3: Estimated biological parameters for oysters in OYS 7 and OYU 5. In the absence of data specific to OYS 7C these estimates are used for management purposes in OYS 7C. [Continued on next page]

1. Natural Mortality (M)

Area	Estimate	Source
Tasman Bay	0.920	Drummond (1994b)
Tasman Bay	0.200	Drummond (1993)
Foveaux Strait	0.042	Dunn et al (1998b)
Foveaux Strait	0.100	Allen (1979)

2. von Bertalanffy growth (change in diameter mm) parameter estimates from OYS 7. t_0 not provided by Osborne (1999).

K	L_{inf}	t_0	Source
0.597	85.43	-	Osborne (1999)
0.99 +/- 0.16 (sd)	67.52	0.11	Brown et al (2008)

3. STOCKS AND AREAS

Fishing within OYS 7C has been limited to two discrete areas; one in parts of Clifford and Cloudy Bays and the other immediately south of Tory Channel, and commercial oyster fishing has not extended south of Cape Campbell. The oyster population in OYS 7C is likely to be biologically isolated from populations in Foveaux Strait (OYU 5) and at the Chatham Islands (OYS 4) on the basis of geographical distance. The populations in OYS 7C and OYS 7 could also be biologically distinct due to their geographical separation that quite likely leads to limited dispersal of larvae between the two areas.

4. STOCK ASSESSMENT

4.1 Estimates of fishery parameters and abundance

A survey of OYS7C was carried out in 2007 (Brown & Horn 2007) and estimates of the number of recruits (oysters unable to pass through a 58 mm ring) and pre-recruits (less than 58 mm) from Clifford and Cloudy Bay are given in Table 4. Dredge efficiency was assumed to be 100% for the purposes of the survey.

Table 4: Estimate of number of recruit and pre-recruit oysters from Brown & Horn (2007).

Year	Area (Ha)	Recruit No.		Pre-recruit No.	
		Estimate	CV %	Estimate	CV %
2007	43 709	19.5 million	19	14 million	19

4.2 Biomass estimates

Estimates of recruited biomass, from the 2007 survey are given in Table 5.

Table 5: Estimate of relative recruited oyster (≥ 58 mm) biomass (t greenweight) in OYS 7C (Brown & Horn 2007).

Year	Area (Ha)	Biomass (t)	CV
2007	43 709	1 778	0.19

4.3 Yield estimates and projections

For new fisheries where there are insufficient data to conduct a yield per recruit analysis, yield can be estimated using the formula from Mace (1988) recommended by the Ministry of Fisheries Science Group (MFish 2008) for calculation of Maximum Constant Yield (MCY).

$$\mathrm{MCY} = 0.25 M \mathrm{B}_0$$

Where B_0 is an estimate of virgin recruited biomass (here assumed to be equal to the recruited biomass estimate from the 2007 survey (1778 t, Brown & Horn 2007) divided by dredge efficiency) and *M* is an estimate of natural mortality. A range of MCY estimates are given in Table 6 using values for dredge efficiency of 100% and 64% (Bull 1989), and values for *M* ranging from 0.1 to 0.3 taken from studies conducted in the Foveaux and Nelson-Marlborough oyster fisheries.

Table 6: Estimates of MCY for *M* of 0.1–0.3. MCY 1 was estimated using a dredge efficiency of 64% from Bull (1989) and MCY 2 was estimated assuming a dredge efficiency of 100%.

M	MCY 1	MCY 2
0.1	69	44
0.2	139	89
0.3	208	133

There are no CAY estimates for OYS 7C.

4.4 Other Yield Estimates
There are no other yield estimates for OYS 7C.

4.5 Other Factors
Dredging for oysters will have an impact on the soft sediment habitats within Cloudy and Clifford Bays, and will affect both the dredge oyster beds and other species found in association with these beds. In addition, various areas within the fishery (mainly around coastal rocky reefs) are understood to support a range of sensitive invertebrate species including soft corals, large erect and divaricating bryozoans, starfish, horse mussels, and crabs. The impacts of dredging are likely to be more severe on these habitats than on soft sediments, and will increase with increasing fishing effort, but there is insufficient information to quantify the degree of impact under any given TAC. There may be some overlap with other fisheries that contact the bottom in this area, but this has not been quantified.

Industry has proposed to voluntarily restrict fishing to two discrete areas to mitigate the effects of fishing. These areas are where oyster densities are highest. By-catch of benthic invertebrates was collected during the biomass survey and could be analysed to help to determine the distribution of sensitive habitats.

5. ENVIRONMENTAL AND ECOSYSTEM CONSIDERATIONS

This section was reviewed by the Aquatic Environment Working Group for inclusion in the Fishery Assessment Plenary November 2014. A broader summary of information on a range of issues related to the environmental effects of fishing and aspects of the marine environment and biodiversity of relevance to fish and fisheries is available in the Aquatic Environment & Biodiversity Annual Review (Ministry for Primary Industries 2013a).

5.1 Role in the ecosystem
Dredge oysters (*Ostrea chilensis*) are benthic, epifaunal, sessile bivalve molluscs that have a relatively limited pelagic larval dispersal phase. They are patchily distributed around the New Zealand coast on a variety of substrates (biogenic reef, gravel, sand, mud) in intertidal to subtidal inshore waters, commonly in depths of up to 60 m or more. Commercially exploited beds of oysters occur in Foveaux Strait (OYU 5), Tasman Bay (OYS 7), and Cloudy and Clifford Bays (OYS 7C). Beds at the Chatham Islands (OYS 4) have potential for commercial exploitation. Oysters play important roles in the ecosystem that include influencing water quality by filtering phytoplankton and other suspended particles from the seawater, linking primary production with higher trophic levels, and acting as ecosystem engineers by stabilising sediments and providing structural habitat (biogenic reef) for other taxa (e.g., algae, ascidians, bryozoans, sponges, echinoderms, worms, molluscs, crustaceans, fish).

5.1.1 Trophic interactions

Oysters are active suspension feeders, consuming phytoplankton suspended in the water column. Their diet is the same as or similar to that of many other suspension feeding taxa, including other bivalves such as scallops, clams, and mussels. Oysters are probably prey for a wide range of invertebrate and fish predators, but published records of known or suspected predators are limited. Reported invertebrate predators of *O. chilensis* include brittlestars (*Ophiopsammus maculata*) (Stead 1971), starfish (*Coscinasterias calamaria* and *Astrostole scabra*) (Cranfield 1979) and flatworms (*Enterogonia orbicularis*) (Handley 2002); suspected invertebrate predators include octopus (*Pinnoctopus cordiformis*) and shell boring gastropods (*Poirieria zelandica*, *Xymeme ambiguous*, and *Xymenella pusillis*) (Brown 2012). Predators of oysters probably change with oyster size. Most mortality of oyster spat (small juveniles) during their first winter appears to result from predation by polychaetes, crabs, and gastropods (Ministry for Primary Industries 2013b).

5.2 Incidental catch (fish and invertebrates)

A range of non-target fish and invertebrate species are caught and discarded by dredge fisheries for *O. chilensis*. No data are available on the level or effect of this incidental catch (bycatch) and discarding by the fisheries. Invertebrate bycatch data are available from dredge surveys of the oyster stocks, and the bycatch of the fisheries is likely to be similar to that of the survey tows conducted in areas that support commercial fishing. Fish bycatch data are generally not recorded on surveys, presumably because fish constitute a small fraction of the total bycatch.

In OYU 5 (Foveaux Strait), Cranfield et al. (1999) summarised the results of Fleming (1952) who sampled the macrofaunal bycatch of oyster fishing in a 'near virgin' area of the fishery in 1950; the bycatch was dominated by the frame-building bryozoan *Cinctipora elegans* (and oysters *O. chilensis*) and included a diverse range of other epifaunal organisms. More recently, presence-absence data on the bycatch of oyster dredging have been recorded during surveys and in fishers' logbooks (Michael 2007). In a specific study of the benthic macrofauna bycatch of the 2001 oyster dredge survey in Foveaux Strait, Rowden et al. (2007) identified at least 190 putative species representing 82 families and 12 phyla; 'Commercial' survey strata were principally characterised by the families Balanidae (barnacles), Mytilidae (mussels), Ophiodermatidae (brittle stars), Ostreidae (oysters), and Pyuridae (tunicates). For the 2007 survey of OYU 5, Michael (2007) listed the percentage occurrence of sessile and motile species caught as bycatch in the survey dredge tows. The five most commonly caught sessile species (excluding oysters) were hairy mussels *Modiolus areolatus* (80% occurrence), barnacles *Balanus* sp. (61%), kina *Evechinus chloroticus* (61%), nesting mussels *Modiolarca impacta* (53%), and ascidians *Pyura pulla* (51%). The five most commonly occurring motile bycatch species were brittlestars *Ophiopsammus maculata* (90% occurrence), circular saw shells (gastropods) *Astraea heliotropium* (80%), hermit crabs *Pagurus novizelandiae* (80%), eight armed starfish *Coscinasterias muricata* (63%), and brown dipple starfish *Pentagonaster pulchellus* (54%). Common bycatch species of oyster dredge surveys in Foveaux Strait were reported by Michael (2007) and are listed below in Table 7.

Table 7: Invertebrate species commonly caught as bycatch in dredge surveys of oysters (*O. chilensis*) in Foveaux Strait. Sourced from Michael (2007). [Continued on next page]

Type	Species
Infaunal bivalves	*Glycymeris modesta* (small dog cockle), *Tawera spissa* (morning star shell), *Tucetona laticostata* (large dog cockle), *Pseudoxyperas elongata* ('tuatua'), *Venericardia purpurata* (purple cockle)
Epifaunal bivalves	*Modioilus areolatus* hairy mussel), *Modiolarca impacta* (nesting mussel), *Aulacomya atra maoriana* (ribbed mussel), *Barbatia novaezelandiae* (ark shell), *Pecten novaezelandiae* (scallop), *Chlamys zelandiae* (lions paw scallop), *Neothyris lenticularis* (large lantern shell), *N. compressa* (compressed lantern shell)
Sponges	*Chondropsis* topsentii (cream sponge), *Crella incrustans* (red-orange sponge), *Dactylia palmata* (finger sponge)
Ascidians	*Pyura pachydermatina* (kaeo), *P. pulla*

Table 7 [Continued]:

Algae	Red algae spp.
Bryozoans	*Celleporaria agglutinans* (hard/plate coral), *Cinctipora elegans (reef-building bryozoan), Horera foliacea* (lace coral), *Hippomenella vellicata* (paper coral), *Tetrocycloecia neozelanica* (staghorn coral), *Orthoscuticella fusiformis* (soft orange bryozoan)
Barnacles and chitons	*Balanus decorus* (large pink barnacle), *Cryptochonchus porosus* (butterfly chiton), *Eudoxochiton nobilis* (noble chiton), *Rhyssoplax canaliculata* (pink chiton)
Starfish, brittlestars, and holothurians	*Coscinasterias muricata* (eight armed starfish), *Pentagonaster pulchellus* (brown dipple starfish), *Ophiosammus maculata* (snaketail brittlestar), *Australostichopus mollis* (sea cucumber)
Crabs	*Pagurus novaezelandiae* (hermit crab), *Eurynolambrus australis* (triangle crab), *Metacarcinus novaezelandiae* (cancer crab), *Nectocarcinus* sp. (red crab)
Urchins	*Evechinus chloroticus* (kina), *Apatopygus recens* (heart urchin), *Goniocidaris umbraculum* (coarse-spined urchin), *Pseudechinus novaezelandiae* (green urchin), *P. huttoni* (white urchin), *P. albocinctus* (red urchin)
Gastropods	*Astraea heliotropium* (circular saw shell), *Alcithoe arabica* (volute), *Argobuccinum pustulosum tumidum, Turbo granosus, Cabestana spengleri, Charonia lampras*
Octopuses	*Pinnoctopus cordiformis* (common octopus), *Octopus huttoni* (small octopus)

In OYS 7 (Tasman/Golden Bays), data on the bycatch of the 1994–2014 dredge surveys have been collected but not analysed, except for preliminary estimation of the 1998–2013 bycatch trajectories (Williams et al. 2014b). The surveys record the bycatch of other target species of scallops (*Pecten novaezelandiae*) and green-lipped mussels (*Perna canaliculus*), and various other non-target bycatch in nine categories (Williams et al. 2014b). Observation of the 2014 survey sampling identified a problem with the way these categorical bycatch data have been recorded which limits their utility (Williams et al. 2014a).

In OYS 7C, a dredge survey of oysters in Cloudy and Clifford Bays was conducted in 2006, and the survey skipper recorded qualitative comments on the bycatch of each tow, which included 'coral', 'sticks and seaweed', shells, volutes, 'red weed', horse mussels, shell with worm, small crabs, mussels, and scallop (Brown & Horn 2006).

In OYS 4 (Chatham Islands), data on the bycatch of a 2013 dredge survey of oysters off the north coast of Chatham Island were recorded (as estimated volumes of different bycatch categories) but not analysed (Williams et al. 2013).

5.3 Incidental catch (seabirds, mammals, and protected fish)

There is no known bycatch of seabirds, mammals or protected fish species from *O. chilensis* oyster fisheries.

5.4 Benthic interactions

There are a variety of benthic habitats in the different oyster fisheries areas, which generally occur either on coarse substrates usually found in areas of high natural disturbance (Foveaux Strait, Cloudy/Clifford Bays and the Chatham Islands) or on fine substrates typical of sheltered areas (Tasman Bay). Benthic habitats within the Foveaux Strait oyster fishery area were classified by Michael (2007) and comprise a variety of sand/gravel/shell flats and waves, rocky patch reef, and biogenic areas. Cranfield et al. (1999) referred to the latter as epifaunal reefs that he defined as "tidally-oriented, linear aggregations of patch reefs formed by the bryozoan *Cinctipora elegans*, cemented by encrusting bryozoans, ascidians, sponges and polychaetes". Cranfield et al.'s papers (Cranfield et al. 1999, Cranfield et al. 2001, Cranfield et al. 2003) suggested that epifaunal reefs are oyster habitat, but Michael's reports (Michael 2007, 2010) state that commercial fishing for oysters is mainly based on sand, gravel, and shell habitats with little epifauna. In Foveaux Strait, commercial oyster dredging occurs within an area of about 1000 km^2 (although only a portion of this is dredged each year), which is about one-third of the overall OYU 5 stock area (Michael 2010). Habitats within the Cloudy/Clifford Bays and the Chatham Islands fisheries areas have not been defined. The benthic habitat within the Tasman Bay oyster fishery area is predominately mud, although to some extent this may have been affected by land-based sedimentation into the bay and homogenisation of the substrate by dredging and trawling (Brown 2012).

It is well known that fishing with mobile bottom contact gears such as dredges has impacts on benthic populations, communities, and their habitats (e.g., see Kaiser et al. 2006, Rice 2006). The effects are not uniform, but depend on at least: "the specific features of the seafloor habitats, including the natural disturbance regime; the species present; the type of gear used, the methods and timing of deployment of the gear, and the frequency with which a site is impacted by specific gears; and the history of human activities, especially past fishing, in the area of concern" (Department of Fisheries and Oceans 2006). In New Zealand, the effects of oyster dredging on the benthos have been studied in Foveaux Strait (OYU 5) (Cranfield et al. 1999, Cranfield et al. 2001, Cranfield et al. 2003, Michael 2007) and Tasman/Golden Bays (OYS 7) (Tuck et al. 2011). The results of these studies are summarised in the Aquatic Environment & Biodiversity Annual Review (Ministry for Primary Industries 2013a), and are consistent with the global literature: generally, with increasing fishing intensity there are decreases in the density and diversity of benthic communities and, especially, the density of emergent epifauna that provide structured habitat for other fauna.

The effects of dredging (Ministry for Primary Industries 2013a) may be more severe in sheltered areas (e.g., Tasman Bay) than in exposed areas (e.g., Foveaux Strait, Cloudy/Clifford Bays, Chatham Islands). Dredging damages epifauna, and erect, structured habitats, such as biogenic/epifaunal reefs, are the most sensitive to dredging disturbance. Dredging destabilises sediment/shell substrates, suspends sediments and increases water turbidity; the sensitivity of habitats to suspended sediments and their deposition probably varies depending on the prevailing natural flow regime, being greater in muddy sheltered areas than in high flow environments. Habitats disturbed by dredging tend to become simpler, more homogenous areas typically dominated by opportunistic species. Dredging generally results in reduced habitat structure and the loss of long-lived species.

For studies of the effects of oyster dredging in Foveaux Strait, interpretation of the authors differ (Ministry for Primary Industries 2013a): "Cranfield et al's papers (Cranfield et al. 1999, Cranfield et al. 2001, Cranfield et al. 2003) concluded that dredging biogenic reefs for their oysters damages their structure, removes epifauna, and exposes associated sediments to resuspension such that, by 1998, none of the original bryozoan reefs remained. Michael (2007) concluded that there are no experimental estimates of the effect of dredging in the strait or on the cumulative effects of fishing or regeneration, that environmental drivers should be included in any assessment, and that the previous conclusions cannot be supported. The authors agree that biogenic bycatch in the fishery has declined over time in regularly-fished areas, that there may have been a reduction in biogenic reefs in the strait since the 1970s, and that simple biogenic reefs appear able to regenerate in areas that are no longer fished (dominated by byssally attached mussels or reef-building bryozoans). There is no consensus that reefs in Foveaux Strait were (or were not) extensive or dominated by the bryozoan *Cinctipora*."

Some areas of the Foveaux Strait (OYU 5) oyster fishery are also commercially fished (potted) for blue cod (*Parapercis colias*), and Cranfield et al. (2001) presented some evidence to suggest that dredged benthic habitats and blue cod densities regenerated in the absence of oyster dredging. Bottom trawling also occurs within the OYU 5 area, but there is little overlap with the main areas fished for oysters. In OYS 7, other benthic fisheries (e.g. bottom trawl, scallop, green-lipped mussel) occur and probably also interact with oysters and their habitats.

5.5 Other considerations

5.5.1 Spawning disruption

Fishing during spawning may disrupt spawning activity or success. In the Foveaux Strait fishery, the traditional harvesting period (1 March to 31 August) occurs after the main spring and summer peaks in oyster spawning activity (Jeffs & Hickman 2000). Fishing-induced damage to oysters incurred during the period before spawning could interrupt gamete maturation. Oyster fishing also targets high-density beds of oysters, which are disproportionately more important for fertilisation success during spawning.

5.5.2 Habitat of particular significance for fisheries management

None currently identified.

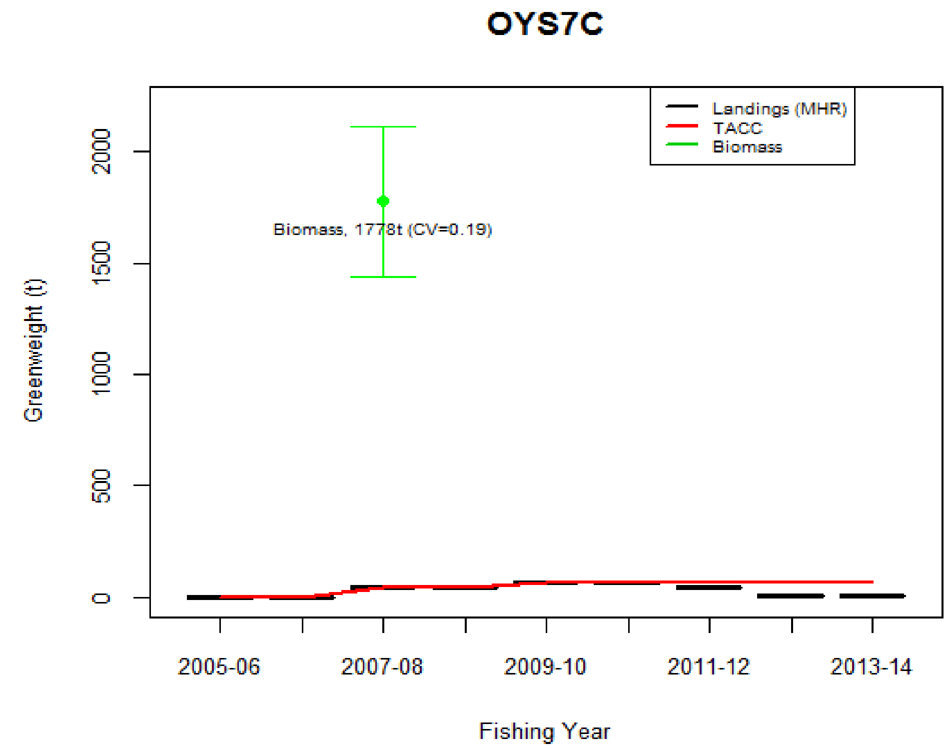
6. STOCK STATUS

Stock Structure Assumptions

Current management assumes that the OYS 7C oyster fishery is separate from the other oyster fisheries (i.e., Challenger (OYS 7), Foveaux Strait (OYU 5), and the Chatham Islands (OYS4)). The stock structure of OYS 7C is assumed to be a single biological stock. Survey data show that oysters are patchily distributed in the commercial fishery area of OYS 7C and it has been suggested that the oyster populations may be mainly self-recruiting.

Stock Status	
Year of Most Recent Assessment	2009
Reference Points	Target: Default = 40% B_0, with at least a 50% probability of achieving the target Soft Limit: 20% B_0 Hard Limit: 10% B_0 Overfishing threshold: F_{MSY}
Status in relation to Target	Very Likely (> 90%) to be at or above the target
Status in relation to Limits	Based on annual commercial oyster removals of less than 4% of the estimated 2007 stock size, the status is likely to be close to virgin size and is Exceptionally Unlikely (< 1%) to be below the soft and hard limits.
Status in relation to Overfishing	Overfishing is Exceptionally Unlikely (< 1%) to be occurring.

Historical Stock Status Trajectory and Current Status



Estimated relative biomass (t greenweight) of recruited oysters (≥ 58 mm) (solid symbol and error bars denoting CV), TACC (solid red line), and reported landings (dashed black line) in t greenweight since 1998. The biomass estimate is from a 2007 survey and is uncorrected for dredge efficiency. Landings data from MHRs.

Fishery and Stock Trends	
Recent trend in Biomass or Proxy	Only one biomass survey has been conducted, in 2007, from which the recruited biomass was estimated to be 1778 t (assuming 100% dredge efficiency).
Recent trend in Fishing Intensity or Proxy	The OYS 7C commercial fishery got underway in 2007–08; in that fishing year the exploitation rate was an estimated at 0.02 (assuming 100% dredge efficiency).
Other Abundance Indices	-
Trends in Other Relevant Indicator or Variables	Landings were at about the level of the TACC up to and including 2010–11, but were lower in recent years due to oyster grading and marketing requirements.

Projections and Prognosis		
Stock Projections or Prognosis	Quantitative stock projections are unavailable	
Probability of Current Catch or TACC causing Biomass to remain below or to decline below Limits	Soft Limit: Unknown Hard Limit: Unknown	
Probability of Current Catch or TACC causing Overfishing to continue or to commence	Exceptionally Unlikely (<1%)	
Assessment Methodology and Evaluation		
Assessment Type	Level 2: Partial Quantitative Stock Assessment	
Assessment Method	Yields are estimated as a proportion of the survey biomass for a range of assumed values of natural mortality and dredge efficiency.	
Assessment Dates	Latest assessment: 2009	Next assessment: Unknown
Overall Assessment Quality Rank	1 - High Quality	
Main data inputs (rank)	Biomass survey: 2007	1 – High Quality
Period of Assessment	Latest assessment: 2009	Next assessment: Unknown
Data not used (rank)	N/A	
Changes to Model Structure and Assumptions		
Major Sources of Uncertainty	There has been only a single biomass survey of this fishstock and repeat surveys should be scheduled at regular intervals. Natural mortality (M) and dredge efficiency are poorly known but are integral parameters of the method used to estimate yield. There is also major uncertainty about the response of localised populations to fishing.	

Qualifying Comments
Some of the surveyed area was not actively fished up to 2009. There are areas of potential oyster habitat which are not fished due to sanitation concerns and substrate which is marginal for fishing. In 2009, the Shellfish FAWG was asked to evaluate the implications of raising the TACC (of 50 t) by 15–20 t. In 2009 it was considered Very Unlikely (< 10%) that an increase in the TACC of this amount would cause the biomass to decline below the Soft Limit in the next 3 to 5 years. On 1 October 2009 the TACC was changed to 62 t.

Fishery Interactions
There may be some overlap with other fisheries that contact the bottom in this area, but this has not been quantified.

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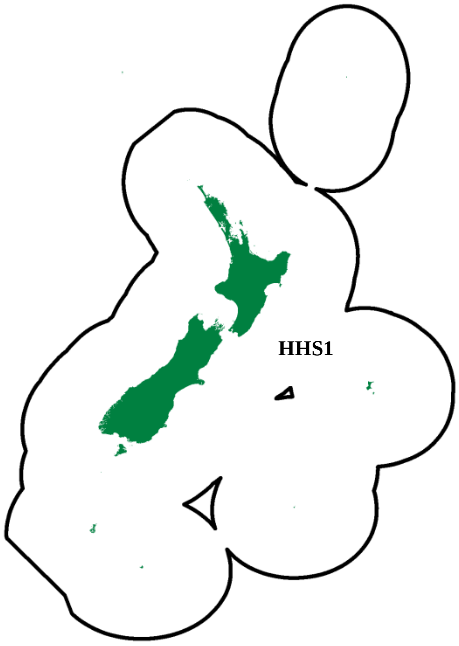
SMOOTH HAMMERHEAD SHARK (HHS)

(*Sphyrna zygaena*)



1. FISHERY SUMMARY

Smooth hammerhead sharks (*Sphyrna zygaena*) are not currently managed under the QMS. No assigned fishing allowances exist. However, as hammerhead sharks have recently been listed as an Appendix II species under CITES it is appropriate to include it in this document.

The Western and Central Pacific Fisheries Commission (WCPFC) has listed hammerhead sharks (as a group) as a key shark species, and the management of smooth hammerhead sharks throughout the western and central Pacific Ocean (WCPO) is the responsibility of the WCPFC. As such New Zealand (who is a signatory to the WCPFC) is responsible for ensuring that the management measures applied within New Zealand fisheries waters are compatible with or better than those of the Commission, and our data collection requirements will allow New Zealand to report catches of hammerhead sharks as required.

1.1 Commercial fisheries

There are no target fisheries for hammerhead sharks in New Zealand. However, they are caught as bycatch in several commercial fisheries within New Zealand fishery waters.

The majority of small hammerhead shark are caught in inshore setnet and bottom longline fisheries (Figure 1). Catches have occurred around the entire northern North Island, with most captures in the Firth of Thames, Hauraki Gulf and eastern Bay of Plenty (Francis 2010) and a small number caught further south (Figures 2-3). A small number of large hammerheads are caught as bycatch in the surface longline fisheries targeting highly migratory species. Across all surface longline fisheries albacore make up the bulk of the catch (32%) . Surface longline fishing effort is distributed along the east coast of the North Island and the south west coast South Island fishery. The west coast South Island fishery predominantly targets southern bluefin tuna, whereas the east coast of the North Island targets a range of species including bigeye tuna, swordfish, and southern bluefin tuna.

It is unknown what proportion of hammerhead sharks are released alive from the surface longline fishery.

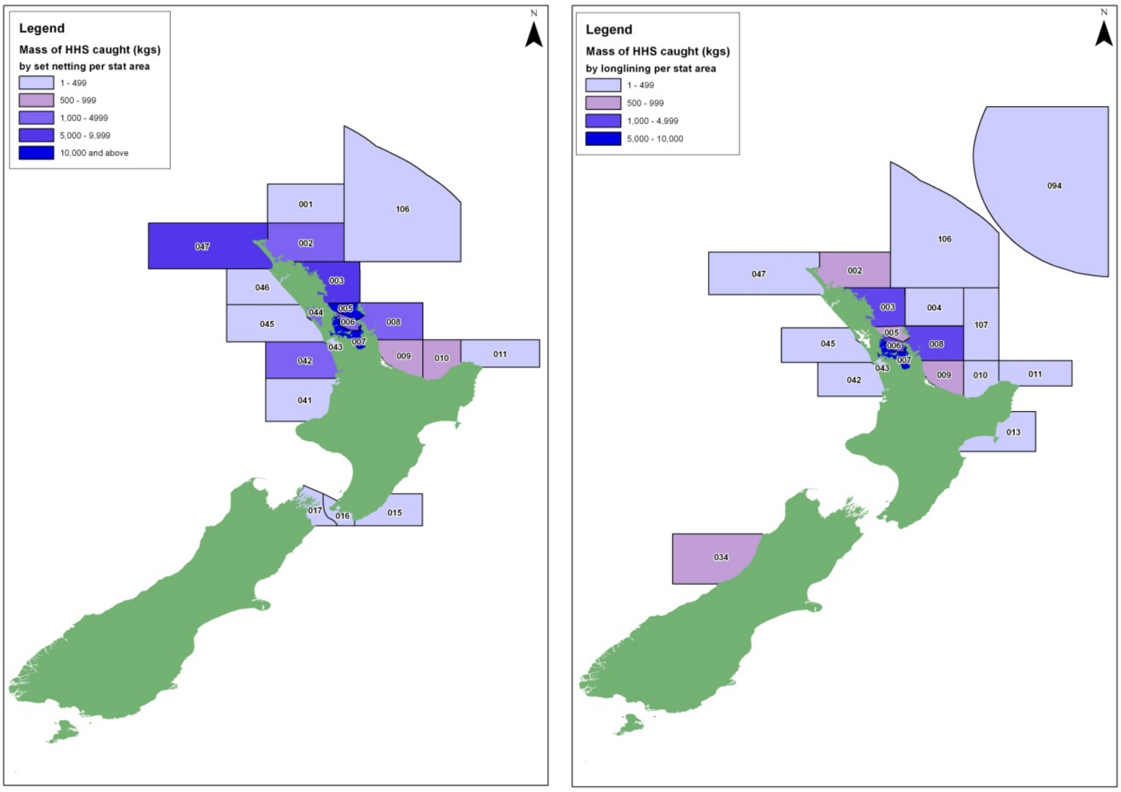


Figure 1: Mass of hammerhead shark per statistical area caught by set net [left] and longline [right] fisheries. These maps have been produced using data extracted from the catch effort database. HHS data from 1 Dec 1989 – 30 June 2013 have been mapped. Only captures where the primary method was set net or longline are included. Data were plotted using the fishing event start position. If no statistical area was supplied, then it was derived using the latitude and longitude. Only records that reported the weight of HHS have been mapped (if no weight was reported, then this is not included on the map).

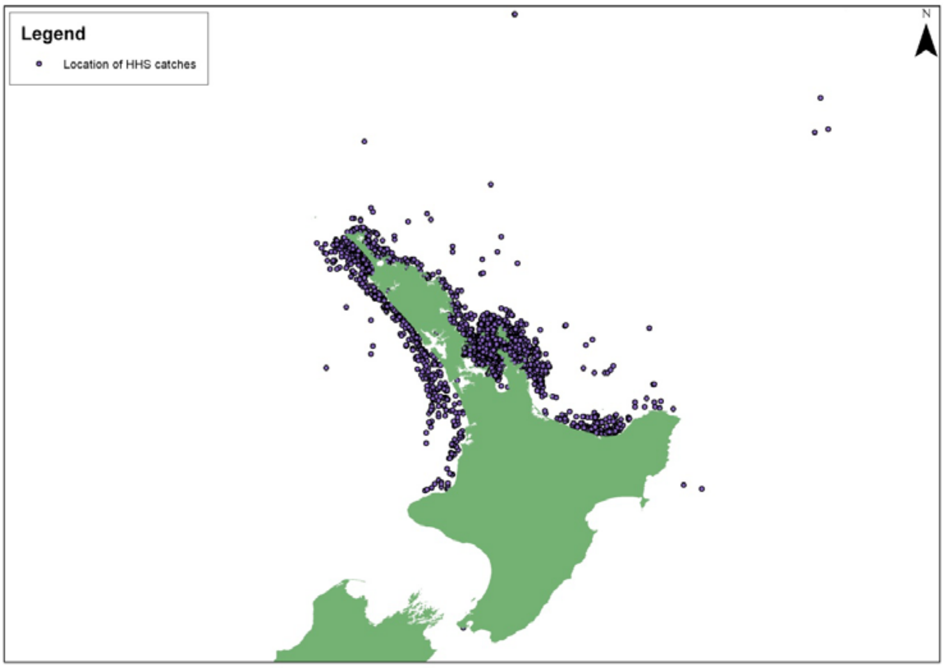


Figure 2: Location of hammerhead shark catches throughout the New Zealand Exclusive Economic Zone. This map has been produced using data extracted from the catch effort database. HHS data from 1 Dec 1989 – 30 June 2013 have been mapped. Data were mapped using the fishing event start position. Only records that reported by latitude and longitude have been included.

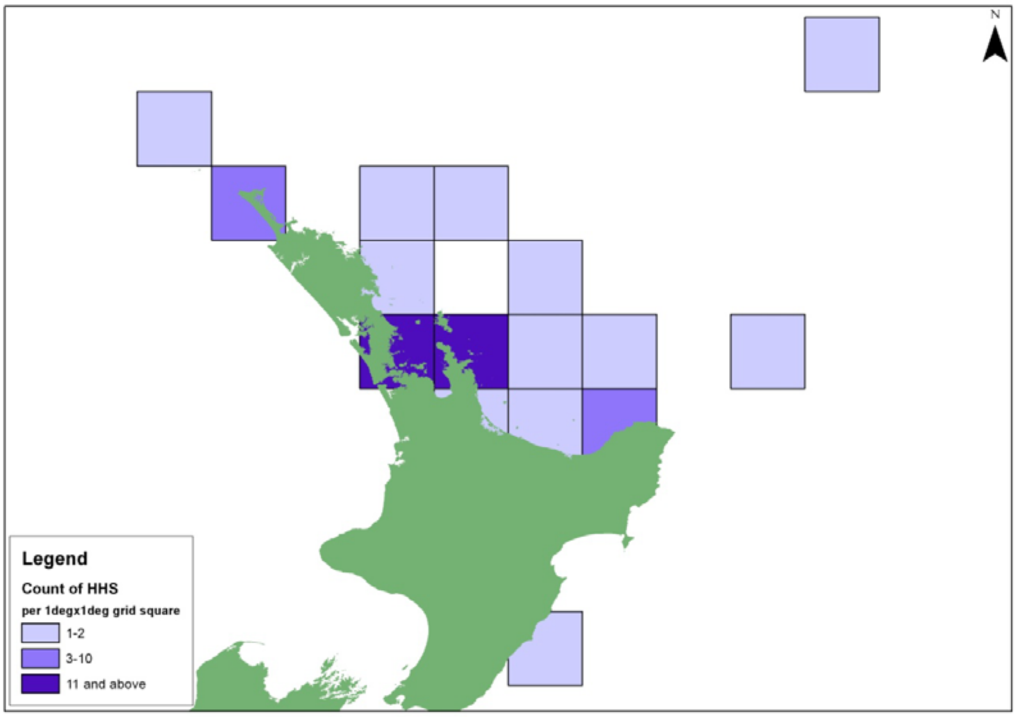


Figure 3: Number of hammerhead shark caught per one degree by one degree grid square. This map has been produced using data extracted from the COD database. HHS data for all years (until 30 June 2013) have been included. The data have been plotted using the start position of the fishing event. Only records that reported the number of HHS caught have been included.

1.2 Recreational fisheries

Hammerhead sharks are rarely targeted by recreational fishers. There may be considerable cryptic bycatch of juveniles in recreational setnets. NIWA staff posted on setnet fishing vessels have recorded large catches of hammerhead sharks in the Hauraki Gulf and Raglan regions. The juveniles captured were rarely taken alive (M. Clark pers comm.).

1.3 Customary non-commercial fisheries

There is no customary non-commercial fishery for hammerhead shark.

1.4 Illegal catch

There is no known illegal catch of hammerhead shark.

1.5 Other sources of mortality

The proportion of sharks discarded dead is unknown. Mortality rates of hammerhead sharks tagged and released by the New Zealand Gamefish Tagging Programme are also unknown.

2. BIOLOGY

Only one species of hammerhead shark (*S. zygaena*) has been recorded from New Zealand waters. However, shark fin identification using protein isoelectric focussing indicated that a second species may occur here, but no clear species identification was made of the second species (P. Smith, NIWA, pers. comm.). Several tropical and subtropical species occur in Australia and the South Pacific Ocean and these may occasionally visit New Zealand.

Juvenile *S. zygaena* are common in shallow coastal waters of the northern North Island, but are relatively absent further south off the east coast of the South Island. Coastal waters appear to serve as a nursery for this species, with highest concentrations occurring in the Firth of Thames, Hauraki Gulf, eastern Bay of Plenty and 90-Mile Beach (Figure 6). Other areas are probably also important (e.g. Kaipara and Manukau Harbours) but data to confirm this are spars.

Length-frequency data from research trawl surveys showed that new-born young first occur in coastal waters during summer at a total length of around 60 cm. These young grow to about 70 cm by the following spring. Larger sharks up to 150 cm probably represent the 1+ and 2+ age classes. Aerial survey observations indicate that juveniles of 150–200 cm total length are abundant off the west coast of North Island. The habitat of adult hammerheads is unknown (Francis 2010).

Although few data are available on the smooth hammerhead's life-history characteristics, it is a large hammerhead shark and presumably at least as biologically vulnerable as the scalloped hammerhead shark (*Sphyrna lewini*) (Casper et al 2005).

3. STOCKS AND AREAS

There is no information on the stock structure of hammerhead sharks.

4. ENVIRONMENTAL AND ECOSYSTEM CONSIDERATIONS

This section was updated for the November 2014 Fishery Assessment Plenary after review by the Aquatic Environment Working Group. This summary is from the perspective of hammerhead shark but there is no directed fishery for them and the incidental catch sections below reflect the New Zealand longline fishery as a whole and are not specific to this species; a more detailed summary from an issue-by-issue perspective is available in the Aquatic Environment and Biodiversity Annual Review where the consequences are also discussed (http://www.mpi.govt.nz/Default.aspx?TabId=126&id=2122) (Ministry for Primary Industries 2013a).

4.1 Role in the ecosystem

The smooth hammerhead shark (*Sphyrna zygaena*) is found worldwide in temperate and tropical seas (Casper et al 2005). It is coastal-pelagic and semi-oceanic and occurs on the continental shelf, to 200 m depth (Ebert 2003). The smooth hammerhead is an active-swimming predator, predominantly feeding on squid and teleosts (Casper et al 2005). Based on specimens caught by recreational anglers off New South Wales, Australia, Stevens (1984) reported that 76% of specimens with food in their stomachs contained squid and 54% teleosts.

4.2 Incidental catch (seabirds, sea turtles and mammals)

The protected species capture estimates presented here are for the surface longline and setnet fisheries in general and include all animals recovered onto the deck (alive, injured or dead) of fishing vessels but do not include any cryptic mortality (e.g., seabirds caught on a hook but not brought onboard the vessel).

4.2.1 Seabird bycatch

Between 2002–03 and 2012–13, there were 818 observed captures of birds across other surface longline target fisheries (those not targeting albacore tuna, bigeye tuna, southern bluefin tuna, pacific bluefin tuna and swordfish). Seabird capture rates since 2003 are presented in Table 1 and Figure 4. Peaks in seabird capture rates occurred in 2006-07 and 2008-09. Seabirds captures were more frequent off the south west coast of the South Island (Figure 5). Bayesian models of varying complexity dependent on data quality have been used to estimate captures across a range of methods (Richard & Abraham 2014). Observed and estimated seabird captures in albacore longline fisheries are provided in Table 2.

Through the 1990s the minimum seabird mitigation requirement for surface longline vessels was the use of a bird scaring device (tori line) but common practice was that vessels set surface longlines primarily at night. In 2007 a notice was implemented under s 11 of the Fisheries Act 1996 to formalise the requirement that surface longline vessels only set during the hours of darkness and use a tori line when setting. This notice was amended in 2008 to add the option of line weighting and tori line use if setting during the day. In 2011 the notices were combined and repromulgated under a new regulation (Regulation 58A of the Fisheries (Commercial Fishing) Regulations 2001) which provides a more flexible regulatory environment under which to set seabird mitigation requirements.

Risk posed by commercial fishing to seabirds has been assessed via a level 2 method which supports much of the NPOA-Seabirds 2013 risk assessment framework (MPI 2013b). The method used in the level 2 risk assessment arose initially from an expert workshop hosted by the Ministry of Fisheries in 2008. The overall framework is described in Sharp et al. (2011) and has been variously applied and improved in multiple iterations (Waugh et al. 2009, Richard et al. 2011, Richard and Abraham 2013, Richard et al. 2013 and Richard & Abraham in press). The method applies an "exposure-effects" approach where exposure refers to the number of fatalities is calculated from the overlap of seabirds with fishing effort compared with observed captures to estimate the species vulnerability (capture rates per encounter) to each fishery group. This is then compared to the population's productivity, based on population estimates and biological characteristics to yield estimates of population-level risk.

The 2014 iteration of the seabird risk assessment (Richard & Abraham in press) assessed other surface longline target fisheries (those not targeting albacore tuna, bigeye tuna, southern bluefin tuna, pacific bluefin tuna and swordfish) contribution to the total risk posed by New Zealand commercial fishing to seabirds (see Table 12). These target fisheries contribute 0.003 of PBR_1 to the risk to Southern Buller's albatross which was assessed to be at very high risk from New Zealand commercial fishing (Richard & Abraham in press).

Table 1: Number of observed seabird captures in the New Zealand surface longline fisheries, 2002–03 to 2012–13, by species and area. See glossary above for a description of the areas used for summarising the fishing effort and protected species captures. The risk ratio is an estimate of aggregate potential fatalities across trawl and longline fisheries relative to the Potential Biological Removals, PBR (from Richard and Abraham (2013) where full details of the risk assessment approach can be found). It is not an estimate of the risk posed by fishing for smooth hammerhead shark using longline gear but rather the total risk for each seabird species. Other data, version 20130305 [Continued on next page].

Albatross Species	Risk Ratio	Kermadec Islands	Northland and Hauraki	Bay of Plenty	East Coast North Island	Stewart Snares Shelf	Fiordland	West Coast South Island	West Coast North Island	Total
Salvin's	Very high	0	1	2	6	0	0	0	0	9
Southern Buller's	Very high	0	5	2	27	0	280	39	0	353
NZ white-capped	Very high	0	2	0	3	10	62	36	1	114
Northern Buller's	High	0	0	0	1	0	0	0	0	1
Gibson's	High	4	16	0	17	0	6	3	1	47
Antipodean	High	12	10	1	8	0	0	0	1	32
Northern royal	Medium	0	0	1	0	0	0	0	0	1
Southern royal	Medium	0	1	0	0	0	4	1	0	6
Campbell black-browed	Medium	2	10	2	29	0	3	3	1	50
Light-mantled sooty	Very low	0	0	0	0	0	0	1	0	1
Unidentified	N/A	38	2	0	2	0	0	0	1	43
Total	**N/A**	**56**	**47**	**8**	**93**	**10**	**355**	**83**	**5**	**657**

Table 1 [Continued]:

Other seabirds

	Risk Ratio	Kermadec Islands	Northland and Hauraki	Bay of Plenty	East Coast North Island	Stewart Snares Shelf	Fiordland	West Coast South Island	West Coast North Island	Total
Black petrel	Very high	1	10	1	0	0	0	0	1	13
Flesh-footed shearwater	Very high	0	0	0	10	0	0	0	2	12
Cape petrel	High	0	0	0	2	0	0	0	0	2
Westland petrel	Medium	0	0	0	2	0	1	6	0	9
White-chinned petrel	Medium	2	3	3	3	1	20	3	3	38
Grey petrel	Medium	3	4	3	38	0	0	0	0	48
Grey-faced petrel	Very low	12	5	1	2	0	0	0	0	20
Sooty shearwater	Very low	1	0	0	8	3	1	0	0	13
Southern giant petrel	-	0	0	2	0	0	0	0	2	0
White-headed petrel	-	2	0	0	0	0	0	0	0	2
Unidentified	N/A	0	1	0	0	0	1	0	0	2
Total	**N/A**	**21**	**23**	**10**	**65**	**4**	**23**	**9**	**8**	**159**

Table 2: Effort, observed and estimated seabird captures by fishing year for the New Zealand surface longline fishery within the EEZ. For each fishing year, the table gives the total number of hooks; the number of observed hooks; observer coverage (the percentage of hooks that were observed); the number of observed captures; the capture rate (captures per thousand hooks); and the mean number of estimated total captures (with 95% confidence interval). Estimates are based on methods described in Thompson et al (2013) are available via http://www.fish.govt.nz/en-nz/Environmental/Seabirds/. Estimates from 2002–03 to 2010–11 and preliminary estimates for 2012–13 are based on data version 20140131.

	Fishing effort			Observed captures		Estimated captures	
Fishing year	All hooks	Observed hooks	% observed	Number	Rate	Mean	95% c.i.
2002–2003	10 772 188	2 195 152	20.4	115	0.052	2 088	1 613–2 807
2003–2004	7 386 329	1 607 304	21.8	71	0.044	1 395	1 086–1 851
2004–2005	3 679 765	783 812	21.3	41	0.052	617	483–793
2005–2006	3 690 119	705 945	19.1	37	0.052	808	611–1 132
2006–2007	3 739 912	1 040 948	27.8	187	0.18	958	736–1 345
2007–2008	2 246 189	421 900	18.8	37	0.088	524	417–676
2008–2009	3 115 633	937 496	30.1	57	0.061	609	493–766
2009–2010	2 995 264	665 883	22.2	135	0.203	939	749–1 216
2010–2011	3 187 879	674 572	21.2	47	0.07	705	532–964
2011–2012	3 100 277	728 190	23.5	64	0.088	829	617–1 161
2012–2013†	2 862 182	560 333	19.6	27	0.048	783	567–1 144

†Provisional data, model estimates not finalised.

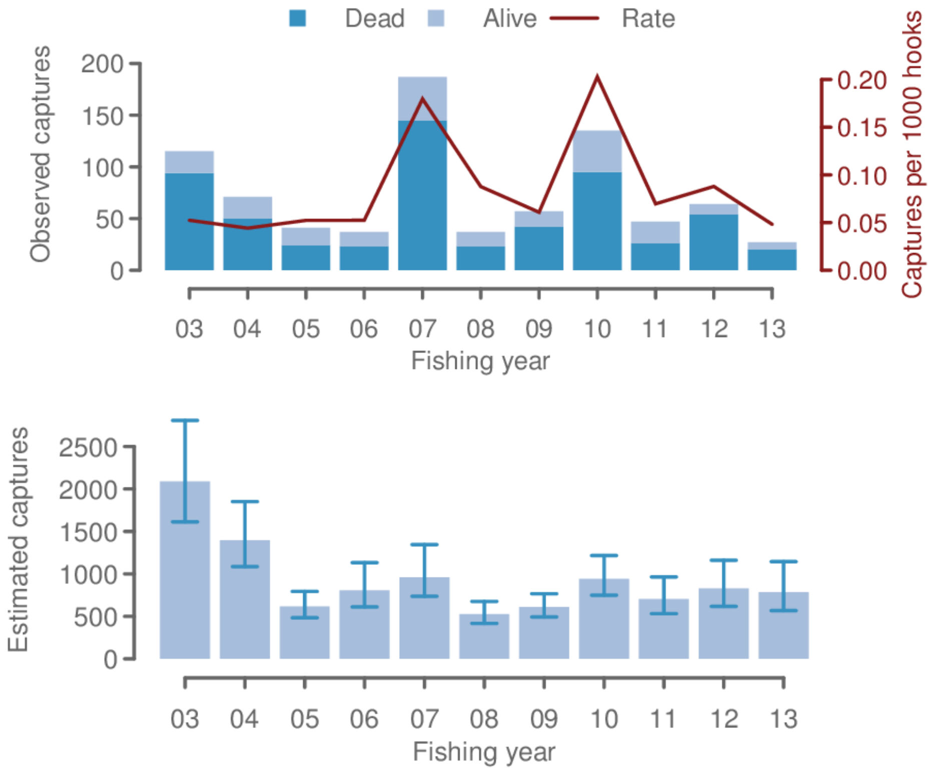


Figure 4: Observed and estimated captures of seabirds in the New Zealand surface longline fisheries from 2002–03 to 2012–13.

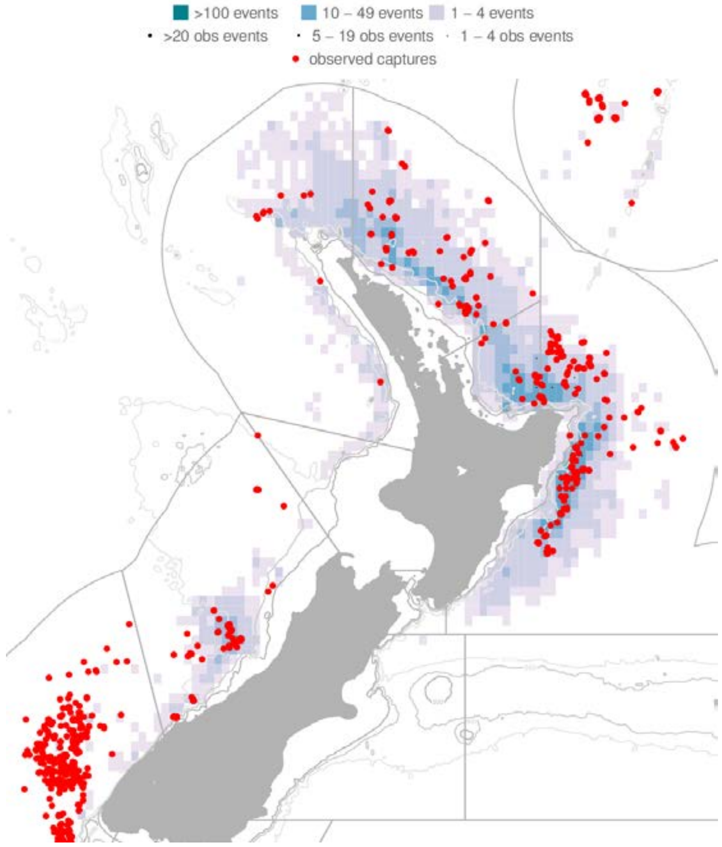


Figure 5: Distribution of fishing effort in the New Zealand surface longline fisheries and observed seabird captures, 2002–03 to 2012–13. Fishing effort is mapped into 0.2-degree cells, with the colour of each cell being related to the amount of effort. Observed fishing events are indicated by black dots, and observed captures are indicated by red dots. Fishing is only shown if the effort could be assigned a latitude and longitude, and if there were three or more vessels fishing within a cell. In this case, 89.4% of the effort is shown. See glossary for areas used for summarising the fishing effort and protected species captures.

Table 3: Risk ratio of seabirds predicted by the level two risk assessment for the other species target surface longline fisheries (those not targeting albacore tuna, bigeye tuna, southern bluefin tuna, pacific bluefin tuna and swordfish) and all fisheries included in the level two risk assessment, 2006–07 to 2012–13, showing seabird species with risk category of very or high, or a medium risk category and risk ratio of at least 1% of the total risk. The risk ratio is an estimate of aggregate potential fatalities across trawl and longline fisheries relative to the Potential Biological Removals, PBR_1 (from Richard and Abraham 2014 where full details of the risk assessment approach can be found). PBR_1 applies a recovery factor of 1.0. Typically a recovery factor of 0.1 to 0.5 is applied (based on the state of the population) to allow for recovery from low population sizes as quickly as possible. This should be considered when interpreting these results. The New Zealand threat classifications are shown (Robertson et al 2013 at http://www.doc.govt.nz/documents/science-and-technical/nztcs4entire.pdf)

	Risk ratio				
Species name	OTH target SLL	Total risk from NZ commercial fishing	% of total risk from NZ commercial fishing	Risk category	NZ Threat Classification
Black petrel	0.000	15.095	0.00	Very high	Threatened: Nationally Vulnerable
Salvin's albatross	0.000	3.543	0.00	Very high	Threatened: Nationally Critical
Southern Buller's albatross	0.003	2.823	0.10	Very high	At Risk: Naturally Uncommon
Flesh-footed shearwater	0.000	1.557	0.00	Very high	Threatened: Nationally Vulnerable
Gibson's albatross	0.000	1.245	0.00	Very high	Threatened: Nationally Critical
New Zealand white-capped albatross	0.000	1.096	0.01	Very high	At Risk: Declining
Chatham Island albatross	0.000	0.913	0.00	High	At Risk: Naturally Uncommon
Antipodean albatross	0.000	0.888	0.00	High	Threatened: Nationally Critical
Westland petrel	0.000	0.498	0.00	High	At Risk: Naturally Uncommon
Northern Buller's albatross	0.000	0.336	0.13	High	At Risk: Naturally Uncommon
Campbell black-browed albatross	0.000	0.304	0.00	High	At Risk: Naturally Uncommon
Stewart Island shag	0.000	0.301	0.00	High	Threatened: Nationally Vulnerable

4.2.2 Sea turtle bycatch

Between 2002–03 and 2012–13, there were 15 observed captures of sea turtles across all surface longline fisheries (Tables 4 and 5, Figure 6). Observer records documented all but one sea turtle as captured and released alive. Sea turtle capture distributions predominantly occur throughout the east coast of the North Island and Kermadec Island fisheries (Figure 7).

Table 4: Number of observed sea turtle captures in the New Zealand surface longline fisheries, 2002–03 to 2012–13, by species and area. Data from Thompson et al (2013), retrieved from http://data.dragonfly.co.nz/psc/. See glossary above for a description of the areas used for summarising the fishing effort and protected species captures.

Species	Bay of Plenty	East Coast North Island	Kermadec Islands	West Coast North Island	Total
Leatherback turtle	1	4	3	3	11
Green turtle	0	1	0	0	1
Unknown turtle	0	1	0	2	3
Total	1	6	3	5	15

Table 5: Effort and sea turtle captures in surface longline fisheries by fishing year. For each fishing year, the table gives the total number of hooks; the number of observed hooks; observer coverage (the percentage of hooks that were observed); the number of observed captures (both dead and alive); and the capture rate (captures per thousand hooks). For more information on the methods used to prepare the data see Thompson et al (2013).

	Fishing effort			Observed captures	
Fishing year	All hooks	Observed hooks	% observed	Number	Rate
2002–2003	10 772 188	2 195 152	20.4	0	0
2003–2004	7 386 329	1 607 304	21.8	1	0.001
2004–2005	3 679 765	783 812	21.3	2	0.003
2005–2006	3 690 119	705 945	19.1	1	0.001
2006–2007	3 739 912	1 040 948	27.8	2	0.002
2007–2008	2 246 189	421 900	18.8	1	0.002
2008–2009	3 115 633	937 496	30.1	2	0.002
2009–2010	2 995 264	665 883	22.2	0	0
2010–2011	3 187 879	674 572	21.2	4	0.006
2011–2012	3 100 277	728 190	23.5	0	0
2012–2013	2 862 182	560 333	19.6	2	0.004

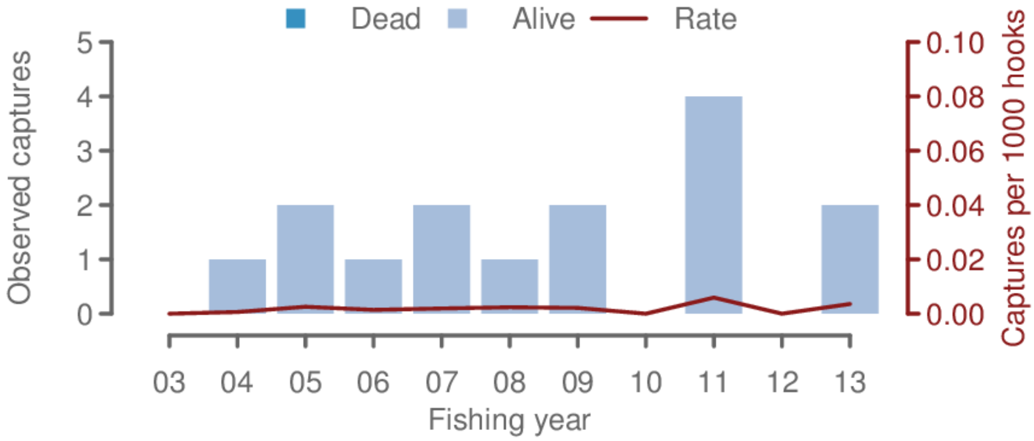


Figure 6: Observed captures of sea turtles in the New Zealand surface longline fisheries from 2002–03 to 2012–13.

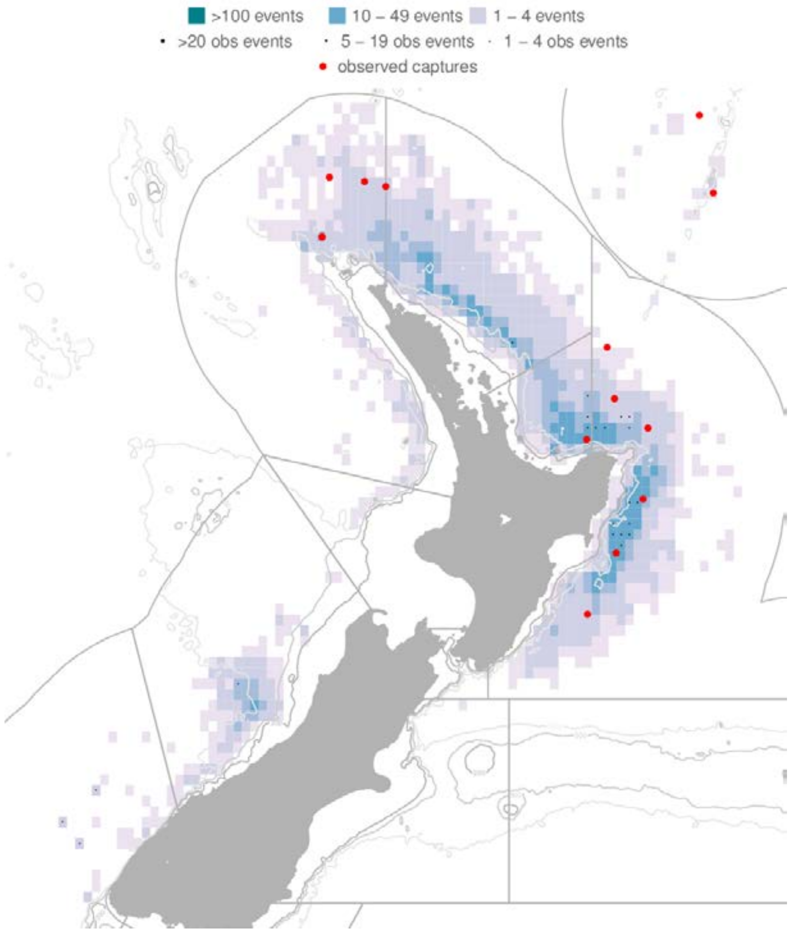


Figure 7: Distribution of fishing effort in the New Zealand surface longline fisheries and observed sea turtle captures, 2002–03 to 2012–13. Fishing effort is mapped into 0.2-degree cells, with the colour of each cell being related to the amount of effort. Observed fishing events are indicated by black dots, and observed captures are indicated by red dots. Fishing is only shown if the effort could be assigned a latitude and longitude, and if there were three or more vessels fishing within a cell. In this case, 89.4% of the effort is shown. See glossary for areas used for summarising the fishing effort and protected species captures.

4.2.3 Marine Mammals

4.2.3.1 Cetaceans

Cetaceans are dispersed throughout New Zealand waters (Perrin et al 2008). The spatial and temporal overlap of commercial fishing grounds and cetacean foraging areas has resulted in cetacean captures in fishing gear (Abraham & Thompson 2009, 2011).

Between 2002–03 and 2012–13, there were seven observed captures of whales and dolphins in surface longline fisheries. Observed captures included 5 unidentified cetaceans and 2 long-finned Pilot whales (Tables 6 and 7, Figure 8) (Thompson et al 2013). All captured animals recorded were documented as being caught and released alive (Thompson et al 2013). Cetacean capture distributions are more frequent off the east coast of the North Island (Figure 9).

Table 6: Number of observed cetacean captures in the New Zealand surface longline fisheries, 2002–03 to 2012–13, by species and area. Data from Thompson et al (2013), retrieved from http://data.dragonfly.co.nz/psc/. See glossary above for a description of the areas used for summarising the fishing effort and protected species captures.

Species	Bay of Plenty	East Coast North Island	Fiordland	Northland and Hauraki	West Coast North Island	West Coast South Island	Total
Long-finned pilot whale	0	1	0	0	0	1	2
Unidentified cetacean	1	1	1	1	1	0	5
Total	1	2	1	1	1	1	7

Table 7: Effort and captures of cetaceans in surface longline fisheries by fishing year. For each fishing year, the table gives the total number of hooks; the number of observed hooks; observer coverage (the percentage of hooks that were observed); the number of observed captures (both dead and alive); and the capture rate (captures per thousand hooks). For more information on the methods used to prepare the data, see Thompson et al (2013).

	Fishing effort			Observed captures	
Fishing year	All hooks	Observed hooks	% observed	Number	Rate
2002–2003	10 772 188	2 195 152	20.4	1	0
2003–2004	7 386 329	1 607 304	21.8	4	0.002
2004–2005	3 679 765	783 812	21.3	1	0.001
2005–2006	3 690 119	705 945	19.1	0	0
2006–2007	3 739 912	1 040 948	27.8	0	0
2007–2008	2 246 189	421 900	18.8	1	0.002
2008–2009	3 115 633	937 496	30.1	0	0
2009–2010	2 995 264	665 883	22.2	0	0
2010–2011	3 187 879	674 572	21.2	0	0
2011–2012	3 100 277	728 190	23.5	0	0
2012–2013	2 862 182	560 333	19.6	0	0

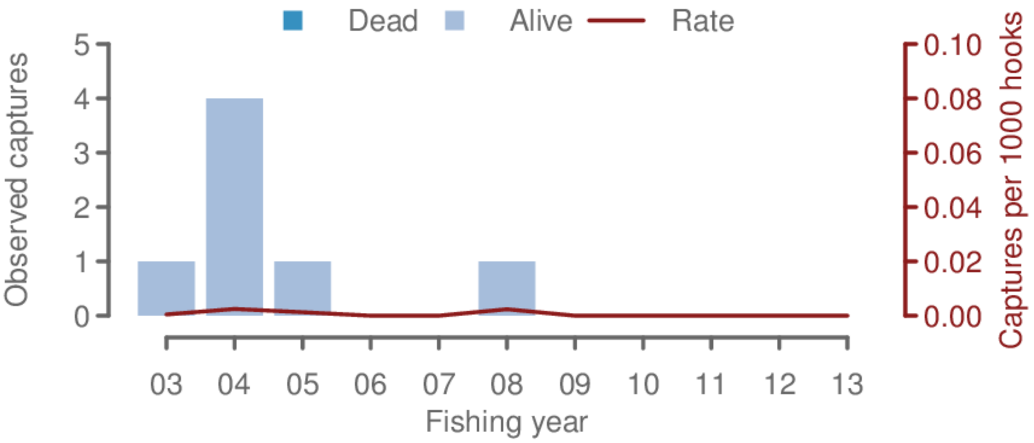


Figure 8: Observed captures of cetaceans in the New Zealand surface longline fisheries from 2002–03 to 2012–13.

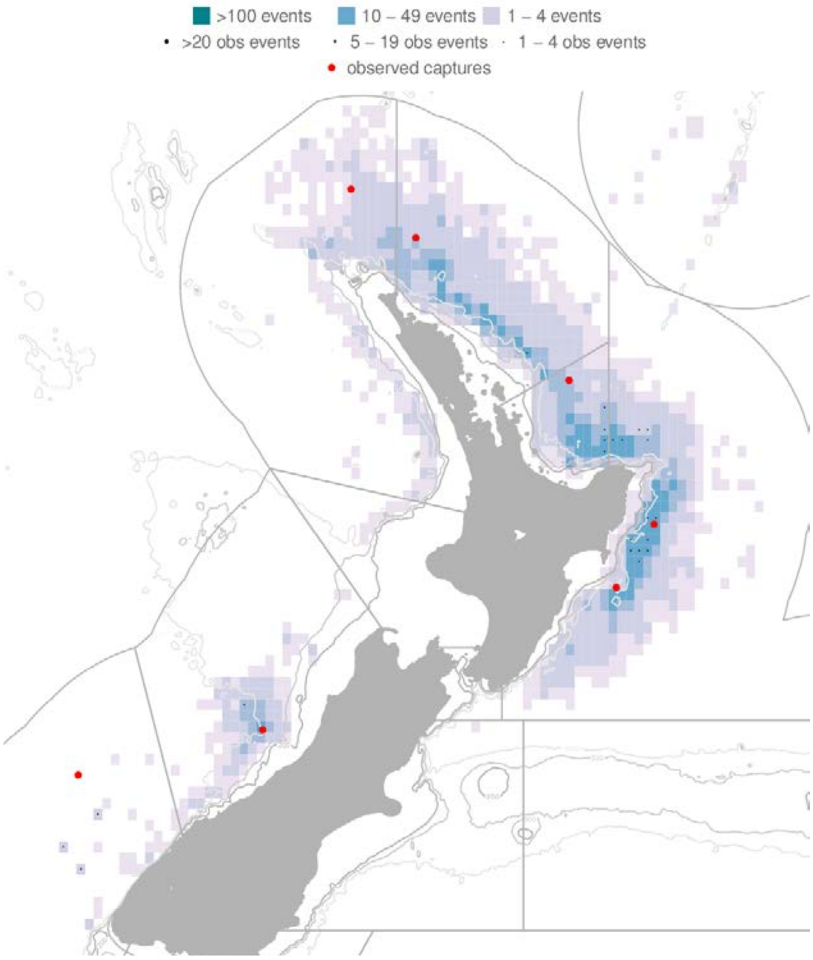


Figure 9: Distribution of fishing effort in the New Zealand surface longline fisheries and observed cetacean captures, 2002–03 to 2012–13. Fishing effort is mapped into 0.2-degree cells, with the colour of each cell being related to the amount of effort. Observed fishing events are indicated by black dots, and observed captures are indicated by red dots. Fishing is only shown if the effort could be assigned a latitude and longitude, and if there were three or more vessels fishing within a cell. In this case, 89.4% of the effort is shown. See glossary for areas used for summarising the fishing effort and protected species captures.

4.2.3.2 New Zealand fur seal bycatch

Currently, New Zealand fur seals are dispersed throughout New Zealand waters, especially in waters south of about 40º S to Macquarie Island. The spatial and temporal overlap of commercial fishing grounds and New Zealand fur seal foraging areas has resulted in New Zealand fur seal captures in fishing gear (Mattlin 1987, Rowe 2009). Most fisheries with observed captures occur in waters over or close to the continental shelf, which slopes steeply to deeper waters relatively close to shore, and thus rookeries and haulouts, around much of the South Island and offshore islands. Captures on longlines occur when the fur seals attempt to feed on the bait and fish catch during hauling. Most New Zealand fur seals are released alive, typically with a hook and short snood or trace still attached.

New Zealand fur seal captures in surface longline fisheries have been generally observed in waters south and west of Fiordland, but also in the Bay of Plenty-East Cape area when the animals have attempted to take bait or fish from the line as it is hauled. These capture rates include animals that are released alive (100% of observed surface longline capture in 2008–09; Thompson & Abraham 2010). Capture rates in 2011–12 and 2012-13 were higher than they were in the early 2000s (Figures 10 and 11). While fur seal captures have occurred throughout the range of this fishery most New Zealand captures have occurred off the Southwest coast of the South Island (Figure 12). Between 2002–03 and 2012–13, there were 267 observed captures of New Zealand fur seal in surface longline fisheries (Tables 8 and 9).

Table 8: Number of observed New Zealand fur seal captures in the New Zealand surface longline fisheries, 2002–03 to 2012–13, by species and area. Data from Thompson et al (2013), retrieved from http://data.dragonfly.co.nz/psc/. See glossary above for a description of the areas used for summarising the fishing effort and protected species captures.

	Bay of Plenty	East Coast North Island	Fiordland	Northland and Hauraki	Stewart Snares Shelf	West Coast North Island	West Coast South Island	Total
New Zealand fur seal	11	33	179	4	4	2	34	267

Table 9: Effort and captures of New Zealand fur seal in the New Zealand surface longline fisheries by fishing year. For each fishing year, the table gives the total number of hooks; the number of observed hooks; observer coverage (the percentage of hooks that were observed); the number of observed captures (both dead and alive); and the capture rate (captures per thousand hooks). Data from Thompson et al (2013), retrieved from http://data.dragonfly.co.nz/psc/. Estimates from 2002–03 to 2010–11 and preliminary estimates for 2012–13 are based on data version 20140131.

	Fishing effort			Observed captures		Estimated captures	
Fishing year	All hooks	Observed hooks	% observed	Number	Rate	Mean	95% c.i.
2002–2003	10 772 188	2 195 152	20.4	56	0.026	299	199–428
2003–2004	7 386 329	1 607 304	21.8	40	0.025	134	90–188
2004–2005	3 679 765	783 812	21.3	20	0.026	66	38–99
2005–2006	3 690 119	705 945	19.1	12	0.017	47	23–79
2006–2007	3 739 912	1 040 948	27.8	10	0.010	32	14–55
2007–2008	2 246 189	421 900	18.8	10	0.024	40	19–68
2008–2009	3 115 633	937 496	30.1	22	0.023	53	29–81
2009–2010	2 995 264	665 883	22.2	19	0.029	77	43–121
2010–2011	3 187 879	674 572	21.2	17	0.025	64	35–101
2011–2012	3 100 277	728 190	23.5	40	0.055	140	92–198
2012–2013†	2 862 182	560 333	19.6	21	0.037	110	65–171

†Provisional data, model estimates not finalised.

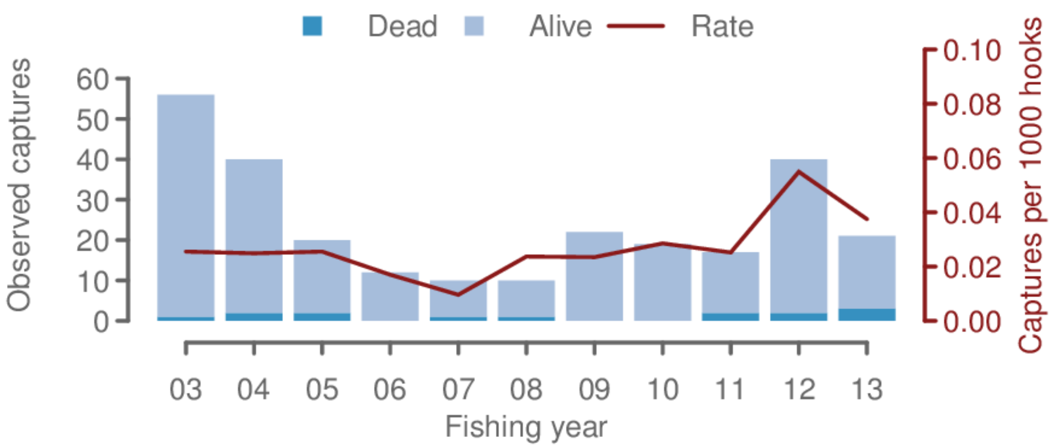


Figure 10: Observed captures of New Zealand fur seal in the New Zealand surface longline fisheries from 2002–03 to 2012–13.

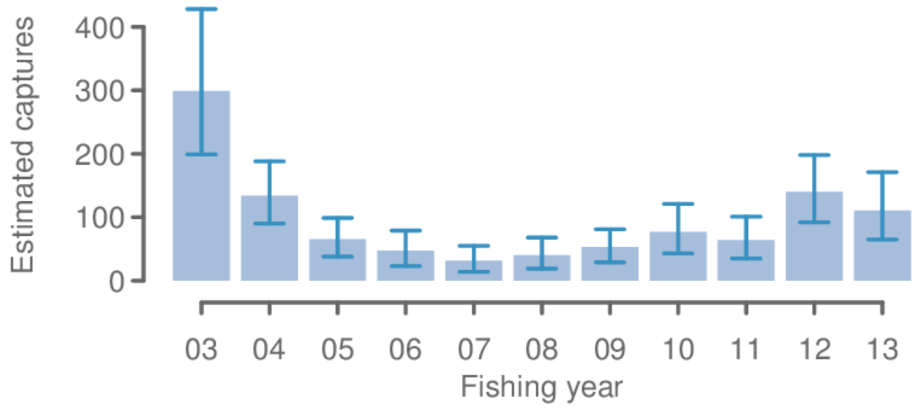


Figure 11: Estimated captures of New Zealand fur seal in the New Zealand surface longline fisheries from 2003 to 2013.

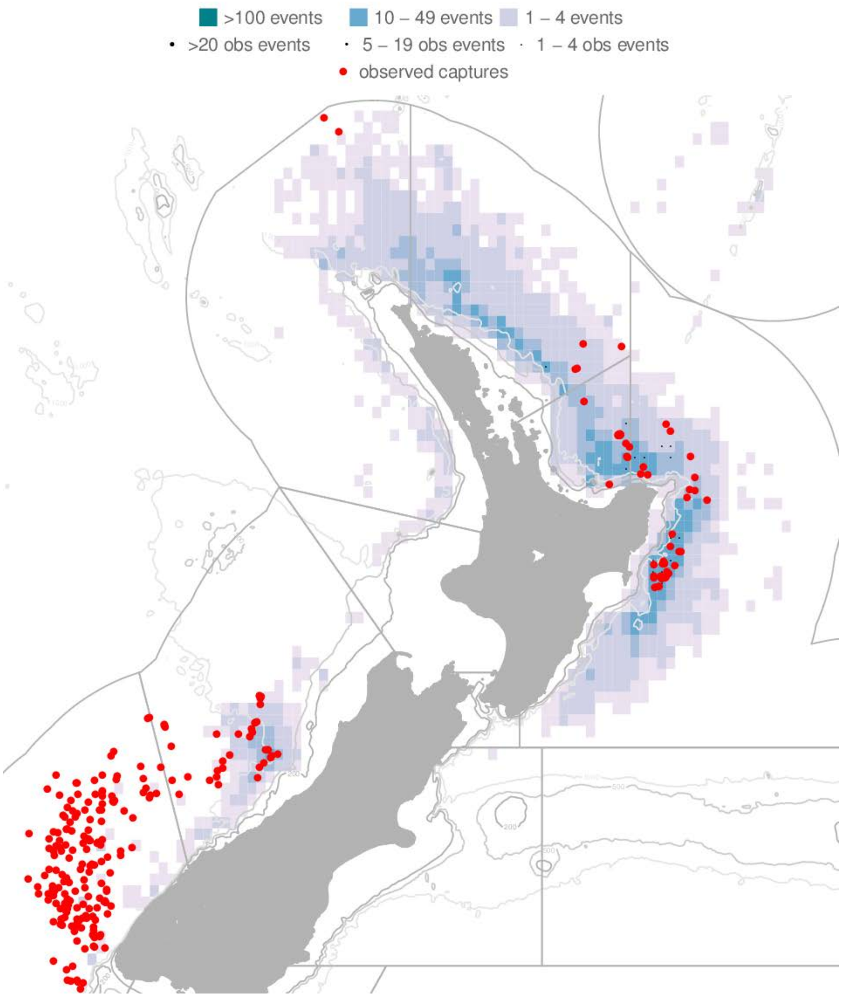


Figure 12: Distribution of fishing effort in the New Zealand surface longline fisheries and observed New Zealand fur seal captures, 2002–03 to 2012–13. Fishing effort is mapped into 0.2-degree cells, with the colour of each cell being related to the amount of effort. Observed fishing events are indicated by black dots, and observed captures are indicated by red dots. Fishing is only shown if the effort could be assigned a latitude and longitude, and if there were three or more vessels fishing within a cell. In this case, 89.4% of the effort is shown. See glossary for areas used for summarising the fishing effort and protected species captures.

4.3 Incidental fish bycatch

Observer records indicate that a wide range of species are landed by the longline fleets in New Zealand fishery waters. Blue sharks are the most commonly landed species (by number), followed by Ray's bream (Table 10). Southern bluefin tuna and albacore tuna are the only target species that occur in the top five of the frequency of occurrence.

Table 10: Total estimated catch (numbers of fish) of common bycatch species in the New Zealand longline fishery as estimated from observer data from 2009 to 2013. Also provided is the percentage of these species retained (2013 data only) and the percentage of fish that were alive when discarded, N/A (none discarded).

Species	2010	2011	2012	2013	% retained (2013)	discards % alive (2013)
Blue shark	66113	53432	132925	158736	45.2	97.4
Lancetfish	43425	37305	7866	19172	0.1	37.6
Rays bream	20041	18453	19918	13568	97.4	4.2
Porbeagle shark	4679	9929	7019	9805	34.0	79.8
Mako shark	4490	9770	3902	3981	35.5	84.9
Moonfish	5398	3418	2363	2470	99.0	0.0
Escolar	1539	6602	2181	2088	30.2	76.3
Sunfish	3148	3773	3265	1937	2.7	100.0
Pelagic stingray	1983	4090	712	1199	1.0	97.0
Butterfly tuna	1158	909	713	1030	48.1	11.1
Deepwater dogfish	377	548	647	743	1.2	88.5
Oilfish	886	1747	509	386	26.5	72.2
Rudderfish	326	338	491	362	13.0	80.0
Thresher shark	209	349	246	256	33.3	75.0
Skipjack tuna	91	255	123	240	100.0	N/A
Dealfish	1160	223	372	237	1.7	25.1
Striped marlin	471	175	124	182	0.0	44.4
Big scale pomfret	505	139	108	67	88.2	100.0
School shark	62	49	477	21	100.0	N/A

4.4 Benthic interactions

N/A

4.5 Key environmental and ecosystem information gaps

Cryptic mortality is unknown at present.

Observer coverage in the New Zealand fleet has historically not been spatially or temporally representative of the fishing effort. However in 2013 the observer effort was re-structured to rectify this by planning observer deployment to correspond with recent spatial and temporal trends in fishing effort.

5. STOCK ASSESSMENT

There is insufficient information with which to conduct a stock assessment of hammerhead sharks.

5.1 Hammerhead shark

5.1.1 Estimates of fishery parameters and abundance

No estimates of fisheries parameters or abundance are available for this species.

5.1.2 Biomass estimates
No estimates of biomass are available for this species.

5.1.3 Yield estimates and projections
Yield estimate and projections has not been estimated for *S. zygaena.*

6. STATUS OF THE STOCKS

Hammerhead sharks in New Zealand are likely to be part of a wider southwestern Pacific Ocean stock. The text below relates only to the New Zealand component of that stock.

Stock Status	
Year of Most Recent Assessment	No assessment
Assessment Runs Presented	-
Reference Points	Target: Not established Soft Limit: Not established by WCPFC; but HSS default of 20% SB_0 assumed Hard Limit: Not established by WCPFC; but HSS default of 10% SB_0 assumed Overfishing threshold: Not established
Status in relation to Target	Unknown
Status in relation to Limits	Unknown
Status in relation to overfishing	Unknown
Historical Stock Status Trajectory and Current Status	
N/A	

Fishery and Stock Trends	
Recent trend in Biomass or Proxy	Unknown
Recent trend in Fishing Intensity or Proxy	Unknown
Other Abundance Indices	Unknown
Trends in Other Relevant Indicators or Variables	Unknown
Projections and Prognosis	
Stock Projections or Prognosis	Unknown
Probability of Current Catch or TACC causing Biomass to remain below or to decline below Limits	Soft Limit: Unknown Hard Limit: Unknown
Probability of Current Catch or TACC causing Overfishing to continue or to commence	Unknown

Assessment Methodology and Evaluation		
Assessment Type	-	
Assessment Method	-	
Assessment Dates	Latest assessment: N/A	Next assessment: none planned
Overall assessment quality rank	-	

Main data inputs (rank)	-	-
Data not used (rank)	-	-
Changes to Model Structure and Assumptions	-	
Major Sources of Uncertainty	-	
Qualifying Comments		
This fishery is largely a bycatch fishery.		

Fishery Interactions
-

7. RESEARCH NEEDS

The key research needs are to determine the link between the New Zealand stock and the wider Pacific stock, and to assess the trends in the stock status for this species.

8. FOR FURTHER INFORMATION

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MAKO SHARK (MAK)

(*Isurus oxyrinchus)*
Mako

1. FISHERY SUMMARY

Mako shark were introduced into the QMS on 1 October 2004 under a single QMA, MAK 1, with a TAC of 542 t, a TACC of 406 t and a recreational allowance of 50 t. The TAC was reviewed in 2012 with the reduced allocation and allowances applied from 1 October 2012 in Table 1. The decrease was in response to sustainability concerns that mako shark is considered to be a risk of overfishing internationally because of its low productivity.

Table 1: Recreational and Customary non-commercial allowances, TACC and TAC (all in tonnes) for mako shark.

Fishstock	Recreational Allowance	Customary non-commercial Allowance	Other mortality	TACC	TAC
MAK 1	30	10	36	200	276

Mako shark was added to the Third Schedule of the 1996 Fisheries Act with a TAC set under s14 because mako shark is a highly migratory species and it is not possible to estimate MSY for the part of the stock that is found within New Zealand fisheries waters.

Mako shark was also added to the Sixth Schedule of the 1996 Fisheries Act with the provision that:

> "A commercial fisher may return any mako shark to the waters from which it was taken from if –
> (a) that mako shark is likely to survive on return; and
> (b) the return takes place as soon as practicable after the mako shark is taken."

Management of the mako shark throughout the western and central Pacific Ocean (WCPO) is the responsibility of the Western and Central Pacific Fisheries Commission (WCPFC). Under this regional convention New Zealand is responsible for ensuring that the management measures applied within New Zealand fisheries waters are compatible with those of the Commission.

1.1 Commercial fisheries

Most of the commercial catch of mako sharks is taken by tuna longliners and bottom longliners and they are also incidental bycatch of bottom and mid-water trawlers. Before the introduction of a ban on shark finning that took effect on 1 October 2014, about 25% of mako sharks caught by tuna longliners were processed and the rest were discarded. The TACC was reduced from 400 t to 200 t for the 2012-13 fishing year.

Landings of mako sharks reported on CELR (landed), CLR, LFRR, and MHR forms are shown in Table 2. The total weights reported by fishers were 74–295 t during 1997–98 to 2008–09. Processors reported 74–319 t on LFRRs during1997-98 to 2012-13. There was a steady increase in the weight of mako shark landed between 1997–98 and 2000–01, resulting from a large increase in domestic fishing effort in the tuna longline fishery, and probably also improved reporting. Landings have since declined to one-quarter of the peak landings..

In addition to catch taken within New Zealand fisheries waters, a small amount (< 1 t) is taken by New Zealand longline vessels fishing on the high seas.

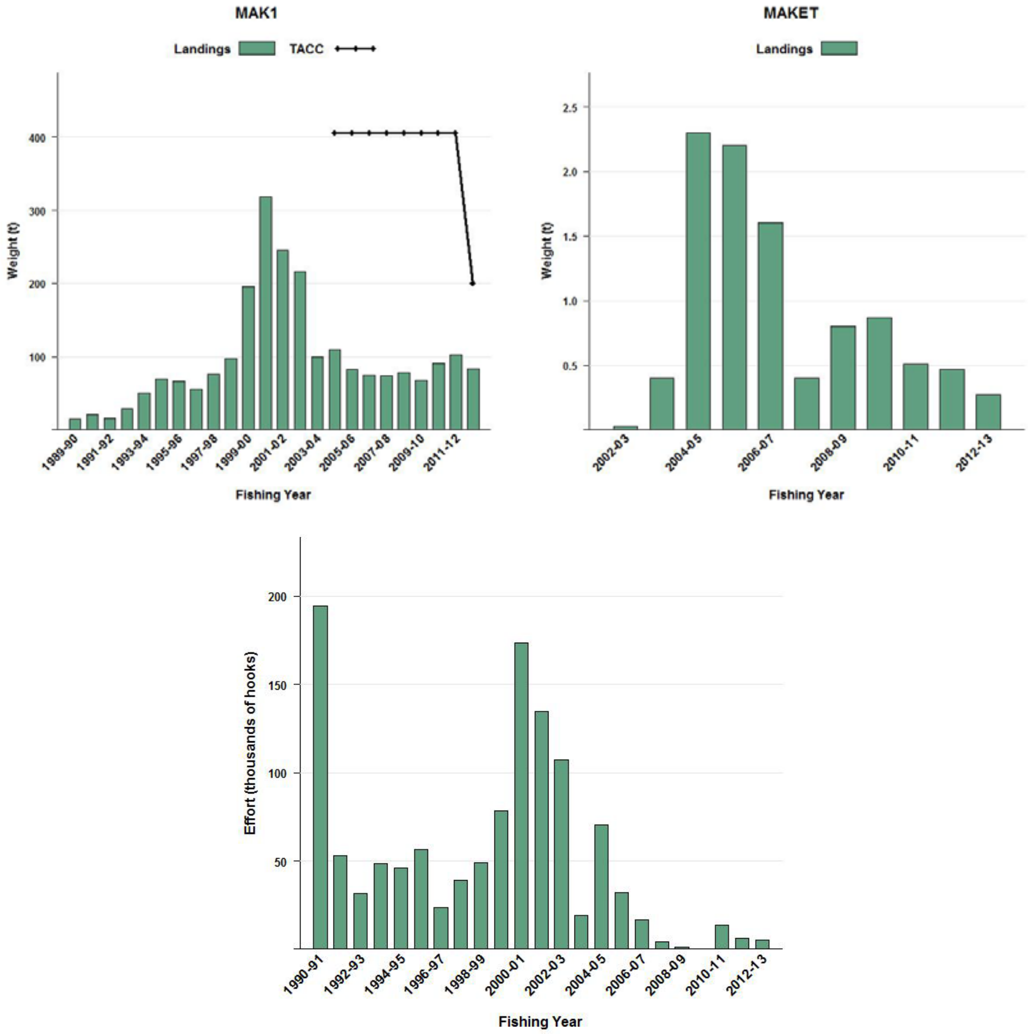


Figure 1: [Top] Mako Shark catch from 1989–90 to 2012–13 within New Zealand waters (MAK 1) and 2002–03 to 2012–13 on the high seas (MAK ET). [Bottom] Fishing effort (number of hooks set) for high seas New Zealand flagged surface longline vessels, from 1990–91 to 2012–13. [Continued on next page].

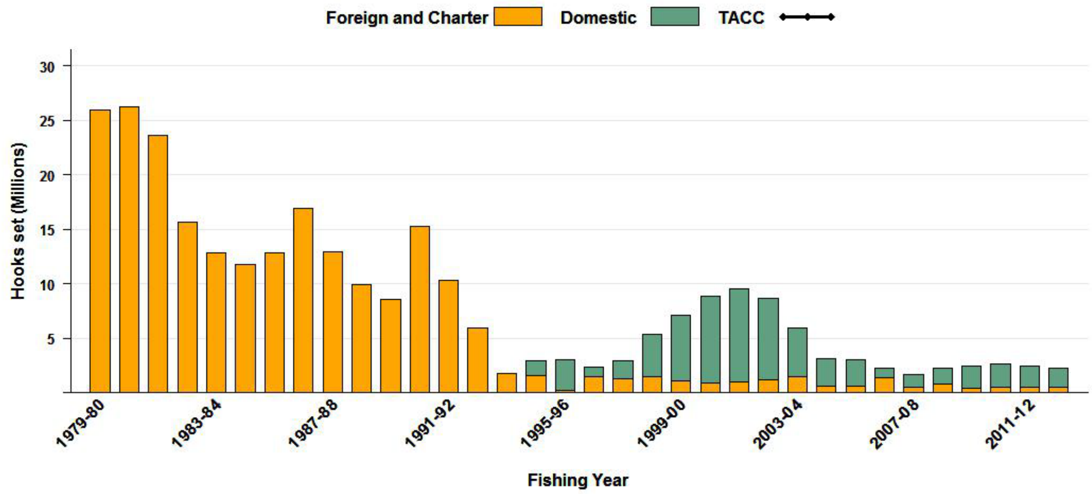


Figure 1 [Continued]: Fishing effort (number of hooks set) for all domestic vessels (including effort by foreign vessels chartered by New Zealand fishing companies), from 1979–80 to 2012–13.

Table 2: New Zealand commercial landings (t) of mako sharks reported by fishers (CELRs and CLRs) and processors (LFRRs) by fishing year.

Year	Total reported	LFRR/MHR
1989–90	11	15
1990–91	15	21
1991–92	17	16
1992–93	24	29
1993–94	44	50
1994–95	63	69
1995–96	67	66
1996–97	51	55
1997–98	86	76
1998–99	93	98
1999–00	148	196
2000–01	295	319
2001–02	242	245
2002–03*	233	216
2003–04*	100	100
2004–05*	107	112
2005–06*	83	84
2006–07*	76	75
2007–08*	72	74
2008–09*	82	78
2009–10*		67
2010–11*		91
2011–12*		103
2012–13*		84

*MHR rather than LFRR data.

Catches of mako sharks aboard tuna longliners are concentrated off the west and southwest coast of the South Island, and the northeast coast of the North Island (Figure 2). Most of the mako landings were taken in FMAs 1 and 2.

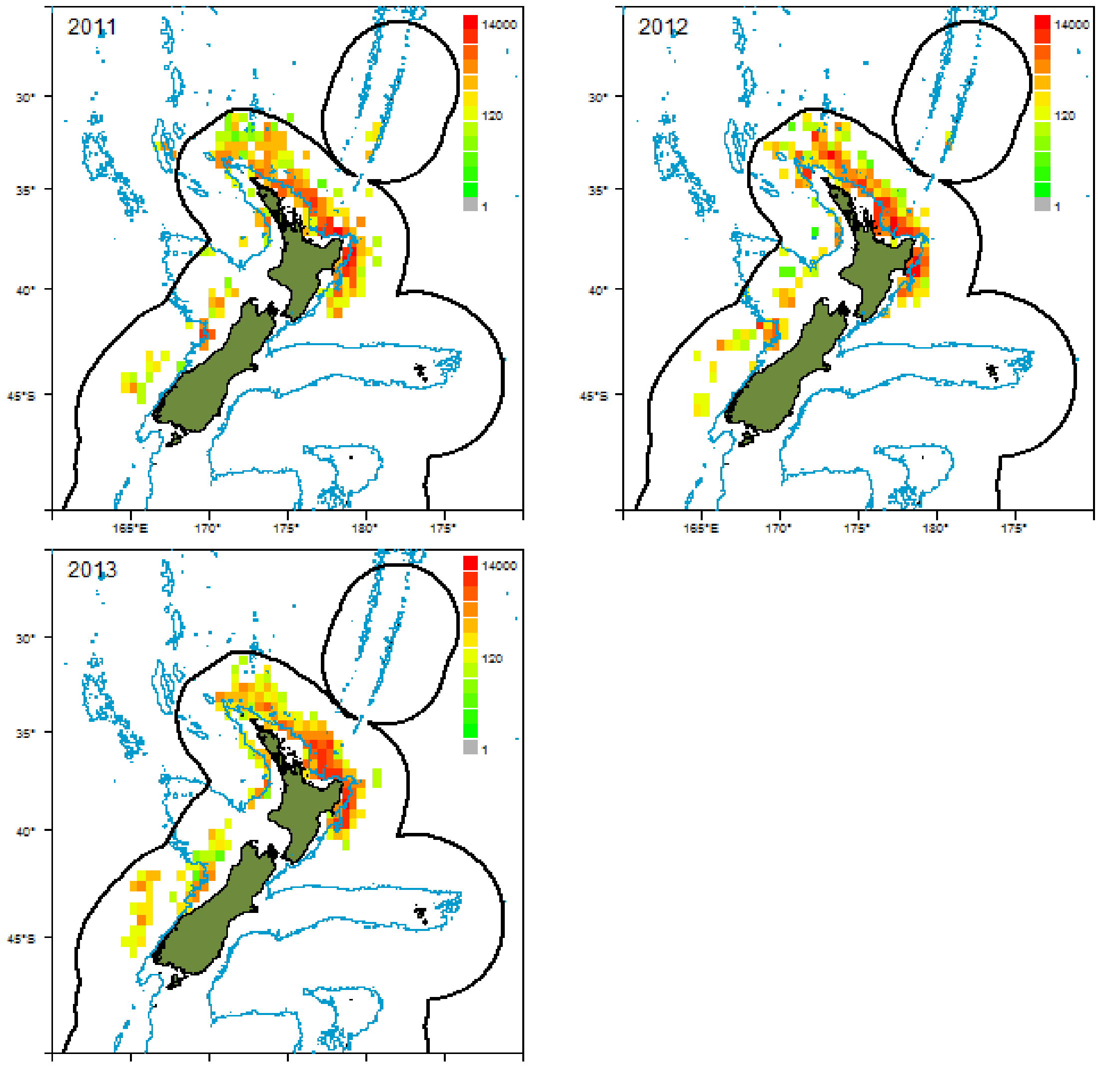


Figure 2: Mako shark catches (kg) by the surface longline fishery in 0.5 degree rectangles by fishing year. Note the log scale used for the colour palette. Depth contour = 1000 m.

The majority of mako shark (58%) are caught in the bigeye tuna target surface longline fishery (Figure 3), across all longline fisheries mako are in the top ten species by weight (3% of reported catches) (Figure 4). Longline fishing effort is distributed along the east coast of the North Island and the south west coast of the South Island. The west coast South Island fishery predominantly targets southern bluefin tuna, whereas the east coast of the North Island targets a range of species including bigeye, swordfish, and southern bluefin tuna (Figure 5).

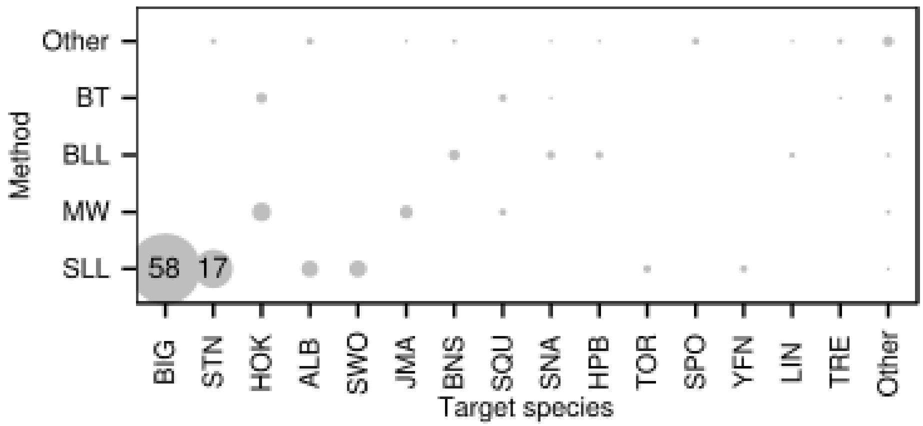


Figure 3: A summary of the proportion of landings of mako shark taken by each target fishery and fishing method. The area of each circle is proportional to the percentage of landings taken using each combination of fishing method and target species. The number in the circle is the percentage. SLL = surface longline, MW = mid-water trawl, BLL = bottom longline, BT = bottom trawl (Bentley et al 2013).

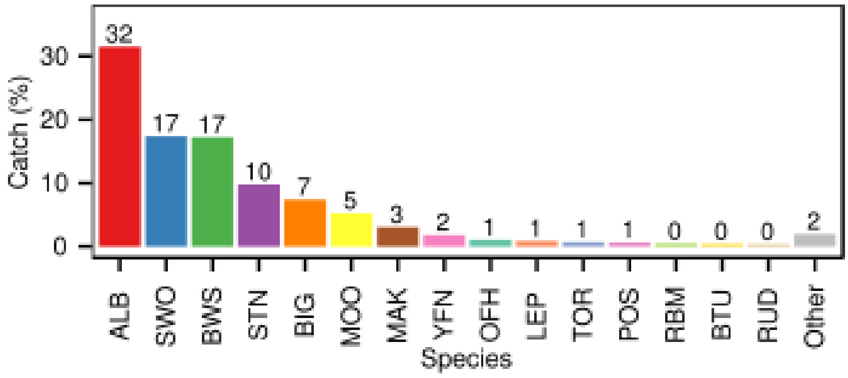


Figure 4: A summary of species composition of the reported surface longline catch. The percentage by weight of each species is calculated for all surface longline trips (Bentley et al 2013).

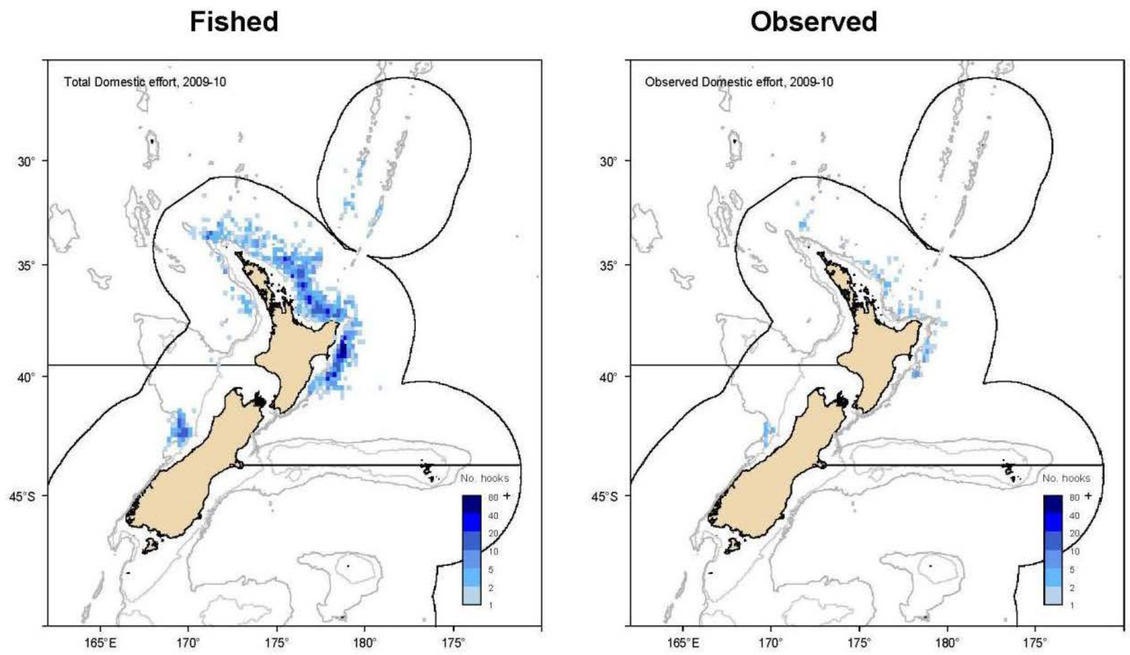


Figure 5: Distribution of fishing positions for domestic (top two panels) and charter (bottom two panels) vessels, for the 2009–10 fishing year, displaying both fishing effort (left) and observer effort (right) [Continued on next page].

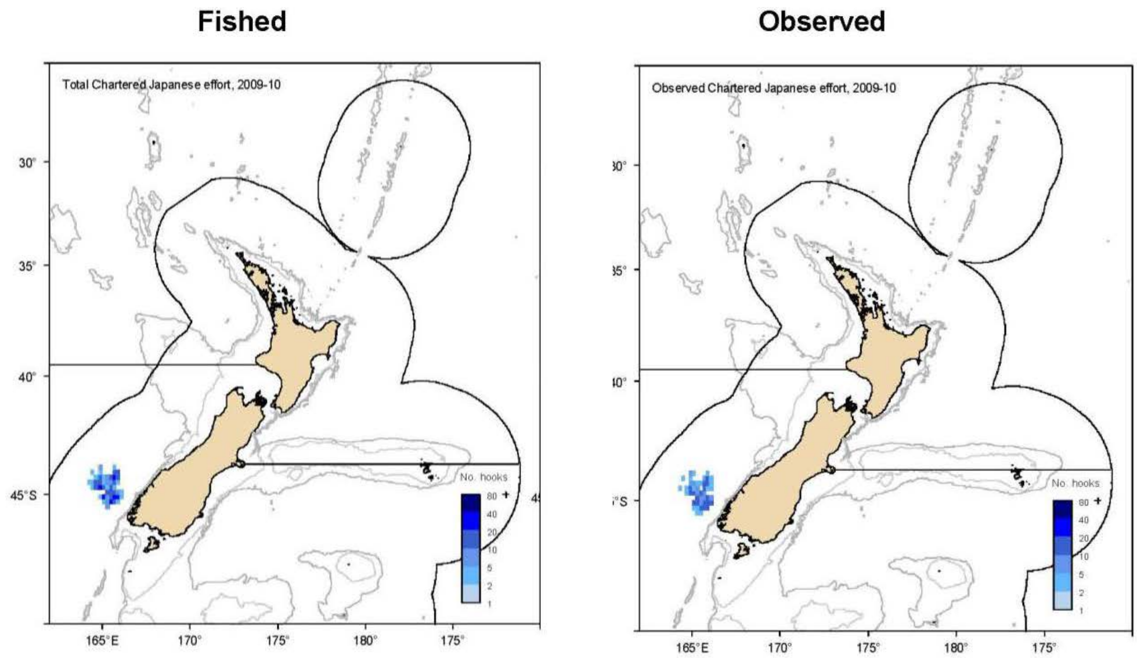


Figure 5 [Continued]: Distribution of fishing positions for domestic (top two panels) and charter (bottom two panels) vessels, for the 2009–10 fishing year, displaying both fishing effort (left) and observer effort (right).

Across all fleets in the longline fishery, 73.6% of the mako sharks were alive when brought to the side of the vessel (Table 3). The domestic fleet retains around 19–67% of their mako shark catch, mostly for the fins, while the foreign charter fleet retains most of the mako sharks (94–100%) (mostly for fins) (Table 4).

Table 3: Percentage of mako shark (including discards) that were alive or dead when arriving at the longline vessel and observed during 2006–07 to 2009–10, by fishing year, fleet and region. Small sample sizes (number observed < 20) were omitted. Griggs & Baird (2013).

Year	Fleet	Area	% alive	% dead	Number
2006–07	Australia	North	82.1	17.9	28
	Charter	North	83.0	17.0	276
		South	93.1	6.9	29
	Domestic	North	67.6	32.4	262
	Total		**76.6**	**23.4**	**595**
2007–08	Domestic	North	63.8	36.2	304
	Total		**64.7**	**35.3**	**320**
2008–09	Charter	North	88.6	11.4	44
		South	100.0	0.0	31
	Domestic	North	69.6	30.4	289
	Total		**74.4**	**25.6**	**367**
2009–10	Domestic	North	76.1	23.9	330
	Total		**75.9**	**24.1**	**348**
Total all strata			73.6	26.4	1 630

Table 4: Percentage of mako shark that were retained, or discarded or lost, when observed on a longline vessel during 2006–07 to 2009–10, by fishing year and fleet. Small sample sizes (number observed < 20) omitted. Griggs & Baird (2013).

Year	Fleet	% retained or finned	% discarded or lost	Number
2006–07	Australia	17.9	82.1	28
	Charter	93.8	6.2	323
	Domestic	37.0	63.0	262
	Total	**66.1**	**33.9**	**613**
2007–08	Domestic	66.6	33.4	305
	Total	**68.2**	**31.8**	**321**
2008–09	Charter	100.0	0.0	85
	Domestic	58.7	41.3	293
	Total	**68.0**	**32.0**	**378**
2009–10	Domestic	19.1	80.9	350
	Total	21.6	78.4	361
Total all strata		57.3	42.7	1 673

1.2 Recreational fisheries
Historically there was a recreational target fishery for mako sharks and they were highly prized as a sport fish. Most mako sharks are now taken as a bycatch while targeting other species. Reported catch has declined since the mid 1990s. Fishing clubs affiliated to the New Zealand Sports Fishing Council have reported landing 24 mako sharks in 2013–14. In addition recreational fishers tag and release 300 to 500 mako sharks per season.

1.3 Customary non-commercial fisheries
There are no estimates of Maori customary catch of mako sharks. Traditionally, mako were highly regarded by Maori for their teeth, which were used for jewellery. Target fishing trips were made, with sharks being caught by flax rope nooses to avoid damaging the precious teeth.

1.4 Illegal catch
There is no known illegal catch of mako sharks.

1.5 Other sources of mortality
Many of the mako sharks caught by tuna longliners (about 75%) are alive when the vessel retrieves the line. It is not known how many of the sharks that are returned to the sea alive under the provisions of Schedule 6 of the Fisheries Act survive.

2. BIOLOGY

Mako sharks occur worldwide in tropical and warm temperate waters, mainly between latitudes 50°N and 50°S. In the South Pacific, mako are rarely caught south of 40°S in winter–spring (August–November) but in summer–autumn (December–April) they penetrate at least as far as 55°S. Mako sharks occur throughout the New Zealand EEZ (to at least 49°S), but are most abundant in the north, especially during the colder months.

Mako sharks produce live young around 57–69 cm fork length (FL). In New Zealand, male mako sharks mature at about 180-185 cm fork length (Francis and Duffy 2005) (Figure 6) and female mako mature at about 275–285 cm FL (Francis 2005) (Figure 7). The length of the gestation period is uncertain, but is thought to be 18 months with a resting period between pregnancies leading to a two- or three-year pupping cycle. Only one pregnant female has been recorded from New Zealand, but newborn young are relatively common. Litter size is 4–18 embryos. If the reproductive cycle lasts three years, and mean litter size is 12, mean annual fecundity would be 4 pups per year.

Estimates of mako shark age and growth in New Zealand were derived by counting vertebral growth bands, and assuming that one band is formed each year. This assumption has recently been validated for North Atlantic mako sharks. Males and females grow at similar rates until age 7–9 years, after which the relative growth of males declines. In New Zealand, males mature at about 7–9 years and females at 19–21 years. The maximum ages recorded are 29 and 28 years for males and females respectively.

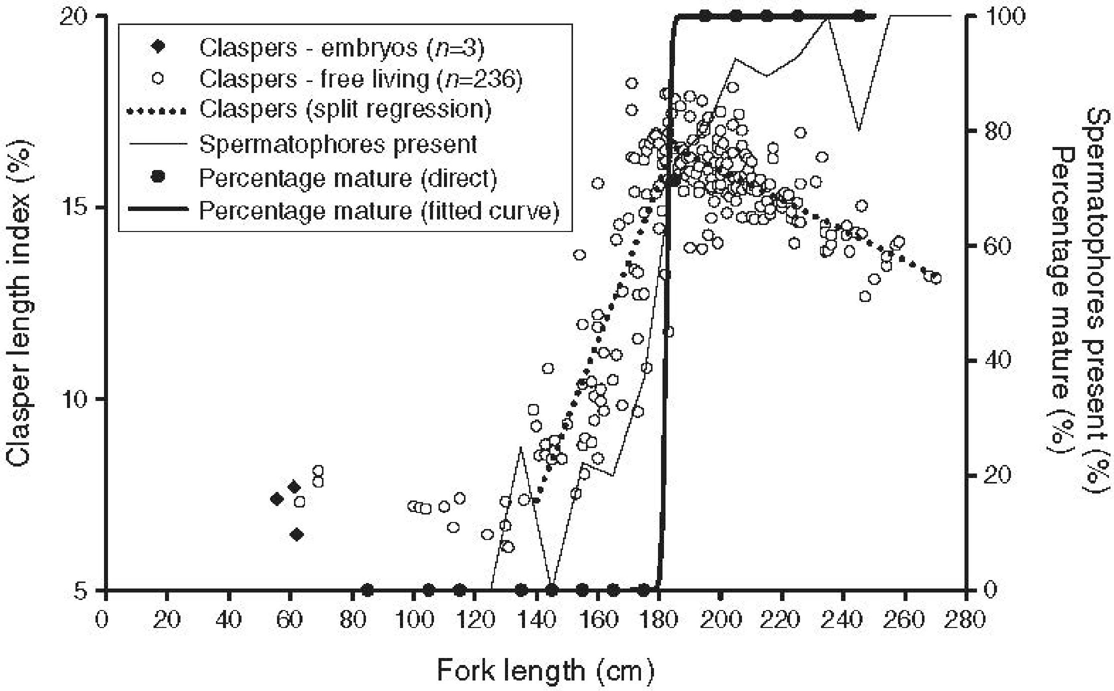


Figure 6: Maturation of male shortfin mako sharks (*Isurus oxyrinchus*): variation in clasper development, presence of spermatophores in the reproductive tract, and direct maturity estimation determined from a suite of maturity indicators (Francis and Duffy 2005).

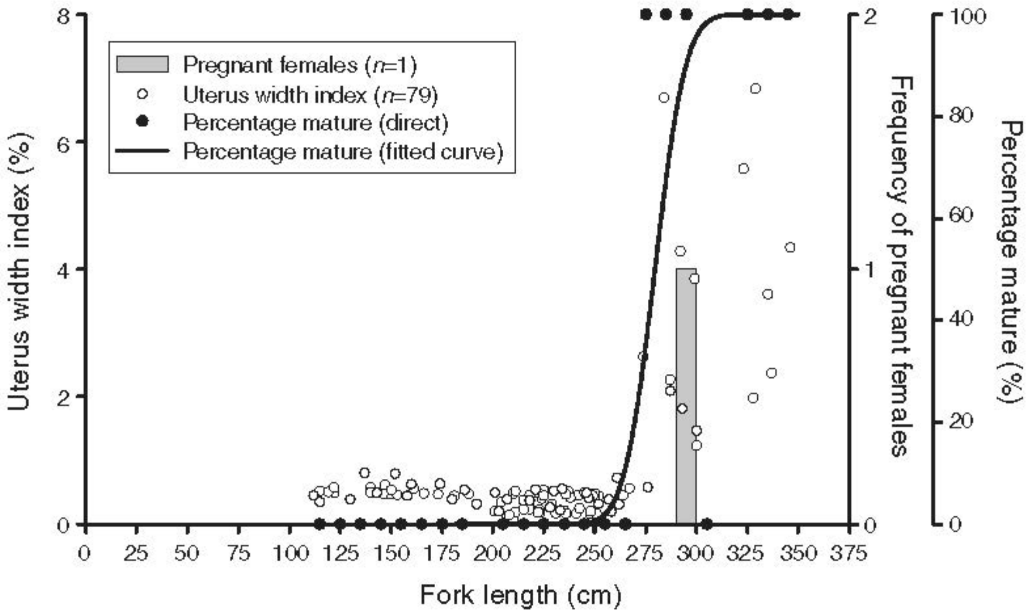


Figure 7: Maturation of female shortfin mako sharks (*Isurus oxyrinchus*): variation in uterus width index, and direct maturity estimation from a suite of maturity indicators. The only pregnant female recorded from New Zealand waters is also indicated (Francis and Duffy 2005).

The longest reliably measured mako appears to be a 351 cm FL female from the Indian Ocean, but it is likely that they reach or exceed 366 cm FL. In New Zealand, mako recruit to commercial fisheries during their first year at about 70 cm FL, and much of the commercial catch is immature. Sharks less than 150 cm FL are rarely caught south of Cook Strait, where most of the catch by tuna longliners consists of sub-adult and adult males.

Mako sharks are active pelagic predators of other sharks and bony fishes, and to a lesser extent squid. As top predators, mako sharks probably associate with their main prey, but little is known of their relationships with other species.

Estimates of biological parameters are given in Table 5.

Table 5: Estimates of biological parameters.

Fishstock	Estimate				Source
1. Natural mortality (M)					
MAK 1	0.10–0.15				Bishop et al (2006)
2. Weight = a(length)^b (Weight in kg, length in cm fork length)					
Both sexes combined	a		b		
MAK 1	2.388×10^{-5}		2.847		Ayers et al (2004)
3. Schnute growth parameters	L_1	L_{10}	κ	γ	
MAK 1 males	100.0	192.1	-	3.40	Bishop et al (2006)
MAK 1 females	99.9	202.9	-0.07	3.67	Bishop et al (2006)

3. STOCKS AND AREAS

Up to June 2014 14 519 mako sharks had been tagged and released in New Zealand waters and 367 recaptured. Most of the tagged fish in recent years were small to medium sharks with estimated total weights at 90 kg or less, with a mode at 40 to 50 kg, and they were mainly tagged off east Northland and the west coast of the North Island. Most recaptures have been within 500 km of the release site, with sharks remaining around east Northland or travelling to the Bay of Plenty and the west coast of North Island. However, long distance movements out of the New Zealand EEZ are frequent, with mako sharks travelling to Australia or the western Tasman Sea (1500–2000 km), the tropical islands north of New Zealand (New Caledonia, Fiji, Tonga, Solomon Islands; 1500–2400 km) and to the Marquesas Islands in French Polynesia (4600 km).

DNA analysis of mako sharks collected in the North-east Pacific, South-west Pacific (Australia), North Atlantic and South-west Atlantic oceans showed that North Atlantic mako sharks were genetically isolated from those found elsewhere, but there was no significant difference among the remaining sites.

The stock structure of mako sharks in the Southern Hemisphere is unknown. However, given the scale of movements of tagged sharks, it seems likely that sharks in the South-west Pacific comprise a single stock. There is no evidence to indicate whether this stock also extends to the eastern South Pacific or the North Pacific.

4. ENVIRONMENTAL AND ECOSYSTEM CONSIDERATIONS

This section was updated for the November 2014 Fishery Assessment Plenary after review by the Aquatic Environment Working Group. This summary is from the perspective of mako shark but there is no directed fishery for them and the incidental catch sections below reflect the New Zealand longline fishery as a whole and are not specific to this species; a more detailed summary from an issue-by-issue perspective is available in the Aquatic Environment and Biodiversity Annual Review where the consequences are also discussed (http://www.mpi.govt.nz/Default.aspx?TabId=126&id=2122) (Ministry for Primary Industries 2013a).

4.1 Role in the ecosystem

Mako sharks (*Isurus oxyrinchus*) are active pelagic predators of other sharks and bony fishes, and to a lesser extent squid (Figure 8 and Figure 9) (Griggs et al 2007).

4.2 Diet

Throughout their life the diet remains dominated by fish with squid making up a small percentage of their gut contents.

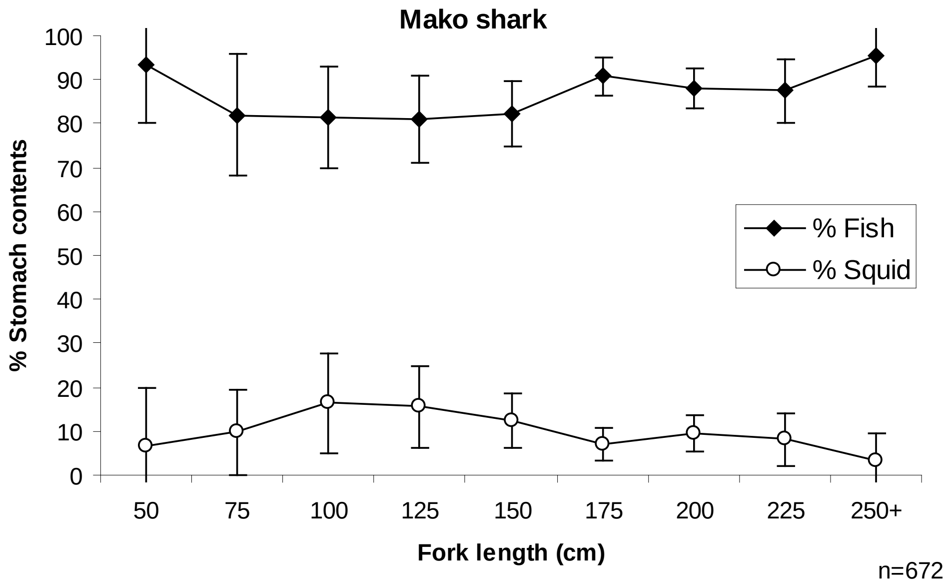


Figure 8: Changes in percentage of fish and squid in stomachs of mako sharks with fork length.

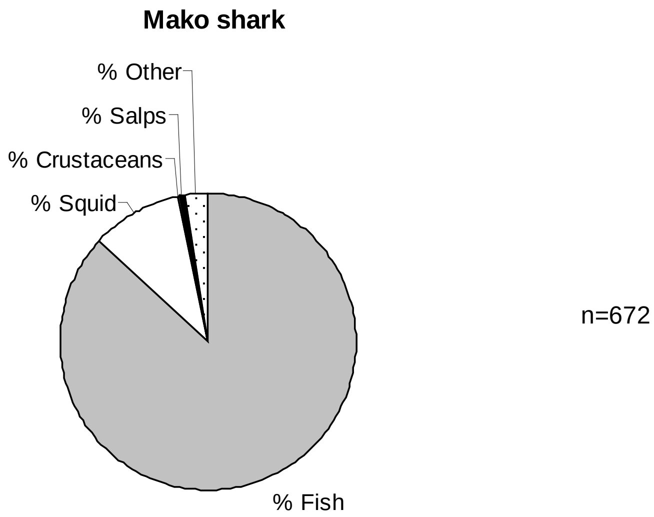


Figure 9: Percentage composition of stomach contents (estimated volumetric) of mako sharks sampled in New Zealand fishery waters.

4.3 Incidental catch (seabirds, sea turtles and mammals)

The protected species, capture estimates presented here include all animals recovered onto the deck (alive, injured or dead) of fishing vessels but do not include any cryptic mortality (e.g., seabirds caught on a hook but not brought onboard the vessel).

4.2.1 Seabird bycatch

Between 2002–03 and 2012–13, there were 818 observed captures of birds other surface longline target fisheries (those not targeting albacore tuna, bigeye tuna, southern bluefin tuna, pacific bluefin tuna and swordfish). Seabird capture rates since 2003 are presented in Table 6 and Figure 10. Seabird captures were more frequent off the south west coast of the South Island (Figure 11). Bayesian models of varying complexity dependent on data quality have been used to estimate captures across a range of methods (Richard & Abraham 2014). Observed and estimated seabird captures in albacore longline fisheries are provided in Table 7.

Through the 1990s the minimum seabird mitigation requirement for surface longline vessels was the use of a bird scaring device (tori line) but common practice was that vessels set surface longlines primarily at night. In 2007 a notice was implemented under s 11 of the Fisheries Act 1996 to formalise the requirement that surface longline vessels only set during the hours of darkness and use a tori line when setting. This notice was amended in 2008 to add the option of line weighting and tori line use if setting during the day. In 2011 the notices were combined and repromulgated under a new regulation (Regulation 58A of the Fisheries (Commercial Fishing) Regulations 2001) which provides a more flexible regulatory environment under which to set seabird mitigation requirements.

Risk posed by commercial fishing to seabirds has been assessed via a level 2 method which supports much of the NPOA-Seabirds 2013 risk assessment framework (MPI 2013b). The method used in the level 2 risk assessment arose initially from an expert workshop hosted by the Ministry of Fisheries in 2008. The overall framework is described in Sharp et al. (2011) and has been variously applied and improved in multiple iterations (Waugh et al. 2009, Richard et al. 2011, Richard and Abraham 2013, Richard et al. 2013 and Richard & Abraham in press). The method applies an “exposure-effects” approach where exposure refers to the number of fatalities is calculated from the overlap of seabirds with fishing effort compared with observed captures to estimate the species vulnerability (capture rates per encounter) to each fishery group. This is then compared to the population’s productivity, based on population estimates and biological characteristics to yield estimates of population-level risk.

The 2014 iteration of the seabird risk assessment (Richard & Abraham in press) assessed other surface longline target fisheries (those not targeting albacore tuna, bigeye tuna, southern bluefin tuna, pacific bluefin tuna and swordfish) contribution to the total risk posed by New Zealand commercial fishing to seabirds (see Table 8). These target fisheries contribute 0.003 of PBR_1 to the risk to Southern Buller’s albatross which was assessed to be at very high risk from New Zealand commercial fishing (Richard & Abraham in press).

Table 6: Number of observed seabird captures in the New Zealand surface longline fisheries, 2002–03 to 2012–13, by species and area. See glossary above for a description of the areas used for summarising the fishing effort and protected species captures. The risk ratio is an estimate of aggregate potential fatalities across trawl and longline fisheries relative to the Potential Biological Removals, PBR (from Richard and Abraham (2013) where full details of the risk assessment approach can be found). It is not an estimate of the risk posed by fishing for mako shark using longline gear but rather the total risk for each seabird species. Other data, version 20130305.

Albatross Species	Risk Ratio	Kermadec Islands	Northland and Hauraki	Bay of Plenty	East Coast North Island	Stewart Snares Shelf	Fiordland	West Coast South Island	West Coast North Island	Total
Salvin's	Very high	0	1	2	6	0	0	0	0	9
Southern Buller's	Very high	0	5	2	27	0	280	39	0	353
NZ white-capped	Very high	0	2	0	3	10	62	36	1	114
Northern Buller's	High	0	0	0	1	0	0	0	0	1
Gibson's	High	4	16	0	17	0	6	3	1	47
Antipodean	High	12	10	1	8	0	0	0	1	32
Northern royal	Medium	0	0	1	0	0	0	0	0	1
Southern royal	Medium	0	1	0	0	0	4	1	0	6
Campbell black-browed	Medium	2	10	2	29	0	3	3	1	50
Light-mantled sooty	Very low	0	0	0	0	0	0	1	0	1
Unidentified	N/A	38	2	0	2	0	0	0	1	43
Total	**N/A**	**56**	**47**	**8**	**93**	**10**	**355**	**83**	**5**	**657**

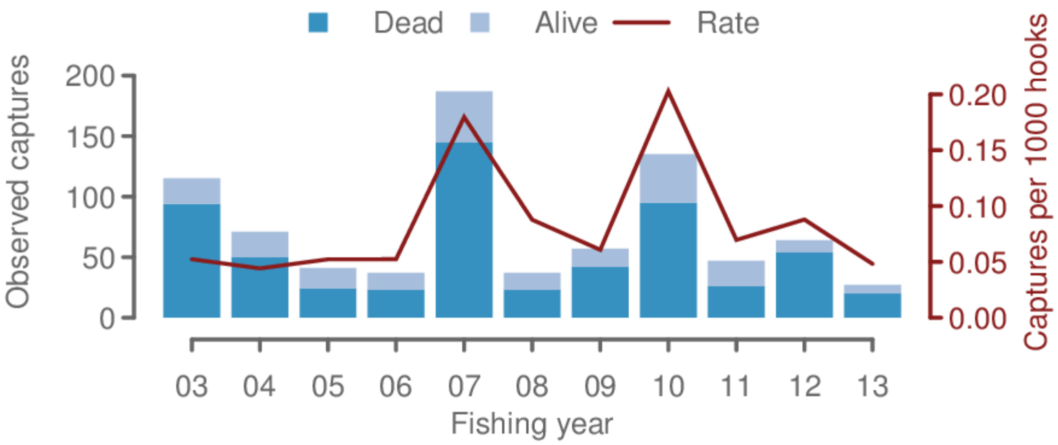
Other seabirds

	Risk Ratio	Kermadec Islands	Northland and Hauraki	Bay of Plenty	East Coast North Island	Stewart Snares Shelf	Fiordland	West Coast South Island	West Coast North Island	Total
Black petrel	Very high	1	10	1	0	0	0	0	1	13
Flesh-footed shearwater	Very high	0	0	0	10	0	0	0	2	12
Cape petrel	High	0	0	0	2	0	0	0	0	2
Westland petrel	Medium	0	0	0	2	0	1	6	0	9
White-chinned petrel	Medium	2	3	3	3	1	20	3	3	38
Grey petrel	Medium	3	4	3	38	0	0	0	0	48
Grey-faced petrel	Very low	12	5	1	2	0	0	0	0	20
Sooty shearwater	Very low	1	0	0	8	3	1	0	0	13
Southern giant petrel	-	0	0	2	0	0	0	0	2	0
White-headed petrel	-	2	0	0	0	0	0	0	0	2
Unidentified	N/A	0	1	0	0	0	1	0	0	2
Total	**N/A**	**21**	**23**	**10**	**65**	**4**	**23**	**9**	**8**	**159**

Table 7: Effort, observed and estimated seabird captures by fishing year for the New Zealand surface longline fishery within the EEZ. For each fishing year, the table gives the total number of hooks; the number of observed hooks; observer coverage (the percentage of hooks that were observed); the number of observed captures; the capture rate (captures per thousand hooks); and the mean number of estimated total captures (with 95% confidence interval). Estimates are based on methods described in Thompson et al (2013) are available via http://www.fish.govt.nz/en-nz/Environmental/Seabirds/. Estimates from 2002–03 to 2010–11 and preliminary estimates for 2012–13 are based on data version 20140131.

	Fishing effort			Observed captures		Estimated captures	
Fishing year	All hooks	Observed hooks	% observed	Number	Rate	Mean	95% c.i.
2002–2003	10 772 188	2 195 152	20.4	115	0.052	2 088	1 613–2 807
2003–2004	7 386 329	1 607 304	21.8	71	0.044	1 395	1 086–1 851
2004–2005	3 679 765	783 812	21.3	41	0.052	617	483–793
2005–2006	3 690 119	705 945	19.1	37	0.052	808	611–1 132
2006–2007	3 739 912	1 040 948	27.8	187	0.18	958	736–1 345
2007–2008	2 246 189	421 900	18.8	37	0.088	524	417–676
2008–2009	3 115 633	937 496	30.1	57	0.061	609	493–766
2009–2010	2 995 264	665 883	22.2	135	0.203	939	749–1 216
2010–2011	3 187 879	674 572	21.2	47	0.07	705	532–964
2011–2012	3 100 277	728 190	23.5	64	0.088	829	617–1 161
2012–2013†	2 862 182	560 333	19.6	27	0.048	783	567–1 144

†Provisional data, model estimates not finalised.



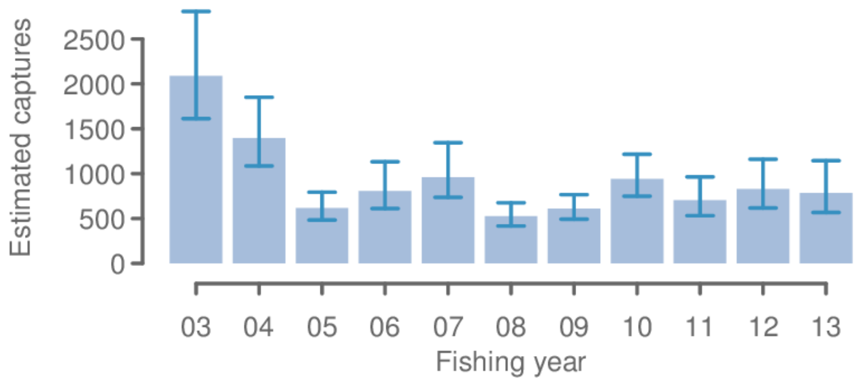


Figure 10: Observed and estimated captures of seabirds in the New Zealand surface longline fisheries from 2002–03 to 2012–13.

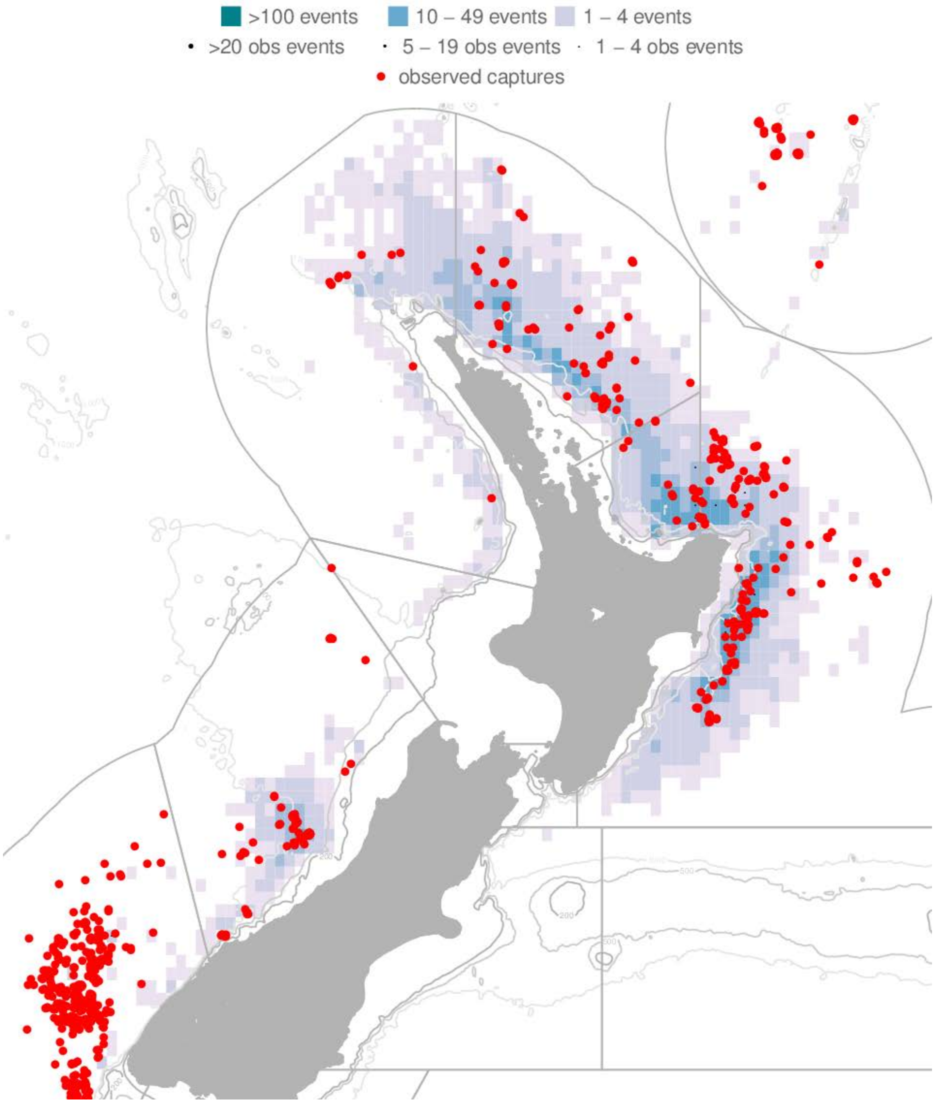


Figure 11: Distribution of fishing effort in the New Zealand surface longline fisheries and observed seabird captures, 2002–03 to 2012–13. Fishing effort is mapped into 0.2-degree cells, with the colour of each cell being related to the amount of effort. Observed fishing events are indicated by black dots, and observed captures are indicated by red dots. Fishing is only shown if the effort could be assigned a latitude and longitude, and if there were three or more vessels fishing within a cell. In this case, 89.4% of the effort is shown. See glossary for areas used for summarising the fishing effort and protected species captures.

Table 8: Risk ratio of seabirds predicted by the level two risk assessment for the other species target surface longline fisheries (those not targeting albacore tuna, bigeye tuna, southern bluefin tuna, pacific bluefin tuna and swordfish) and all fisheries included in the level two risk assessment, 2006–07 to 2012–13, showing seabird species with risk category of very or high, or a medium risk category and risk ratio of at least 1% of the total risk. The risk ratio is an estimate of aggregate potential fatalities across trawl and longline fisheries relative to the Potential Biological Removals, PBR_1 (from Richard and Abraham 2014 where full details of the risk assessment approach can be found). PBR_1 applies a recovery factor of 1.0. Typically a recovery factor of 0.1 to 0.5 is applied (based on the state of the population) to allow for recovery from low population sizes as quickly as possible. This should be considered when interpreting these results. The New Zealand threat classifications are shown (Robertson et al 2013 at http://www.doc.govt.nz/documents/science-and-technical/nztcs4entire.pdf)

	Risk ratio				
Species name	OTH target SLL	Total risk from NZ commercial fishing	% of total risk from NZ commercial fishing	Risk category	NZ Threat Classification
Black petrel	0.000	15.095	0.00	Very high	Threatened: Nationally Vulnerable
Salvin's albatross	0.000	3.543	0.00	Very high	Threatened: Nationally Critical
Southern Buller's albatross	0.003	2.823	0.10	Very high	At Risk: Naturally Uncommon
Flesh-footed shearwater	0.000	1.557	0.00	Very high	Threatened: Nationally Vulnerable
Gibson's albatross	0.000	1.245	0.00	Very high	Threatened: Nationally Critical
New Zealand white-capped albatross	0.000	1.096	0.01	Very high	At Risk: Declining
Chatham Island albatross	0.000	0.913	0.00	High	At Risk: Naturally Uncommon
Antipodean albatross	0.000	0.888	0.00	High	Threatened: Nationally Critical
Westland petrel	0.000	0.498	0.00	High	At Risk: Naturally Uncommon
Northern Buller's albatross	0.000	0.336	0.13	High	At Risk: Naturally Uncommon
Campbell black-browed albatross	0.000	0.304	0.00	High	At Risk: Naturally Uncommon
Stewart Island shag	0.000	0.301	0.00	High	Threatened: Nationally Vulnerable

4.2.2 Sea turtle bycatch

Between 2002–03 and 2012–13, there were 15 observed captures of sea turtles across all surface longline fisheries (Tables 9 and 10, Figure 12). Observer records documented all but one sea turtle as captured and released alive. Sea turtle capture distributions predominantly occur throughout the east coast of the North Island and Kermadec Island fisheries (Figure 13).

Table 9: Number of observed sea turtle captures in the New Zealand surface longline fisheries, 2002–03 to 2012–13, by species and area. Data from Thompson et al (2013), retrieved from http://data.dragonfly.co.nz/psc/. See glossary above for a description of the areas used for summarising the fishing effort and protected species captures.

Species	Bay of Plenty	East Coast North Island	Kermadec Islands	West Coast North Island	Total
Leatherback turtle	1	4	3	3	11
Green turtle	0	1	0	0	1
Unknown turtle	0	1	0	2	3
Total	1	6	3	5	15

Table 10: Effort and sea turtle captures in surface longline fisheries by fishing year. For each fishing year, the table gives the total number of hooks; the number of observed hooks; observer coverage (the percentage of hooks that were observed); the number of observed captures (both dead and alive); and the capture rate (captures per thousand hooks). For more information on the methods used to prepare the data see Thompson et al (2013).

	Fishing effort			Observed captures	
Fishing year	All hooks	Observed hooks	% observed	Number	Rate
2002–2003	10 772 188	2 195 152	20.4	0	0
2003–2004	7 386 329	1 607 304	21.8	1	0.001
2004–2005	3 679 765	783 812	21.3	2	0.003
2005–2006	3 690 119	705 945	19.1	1	0.001
2006–2007	3 739 912	1 040 948	27.8	2	0.002
2007–2008	2 246 189	421 900	18.8	1	0.002
2008–2009	3 115 633	937 496	30.1	2	0.002
2009–2010	2 995 264	665 883	22.2	0	0
2010–2011	3 187 879	674 572	21.2	4	0.006
2011–2012	3 100 277	728 190	23.5	0	0
2012–2013	2 862 182	560 333	19.6	2	0.004

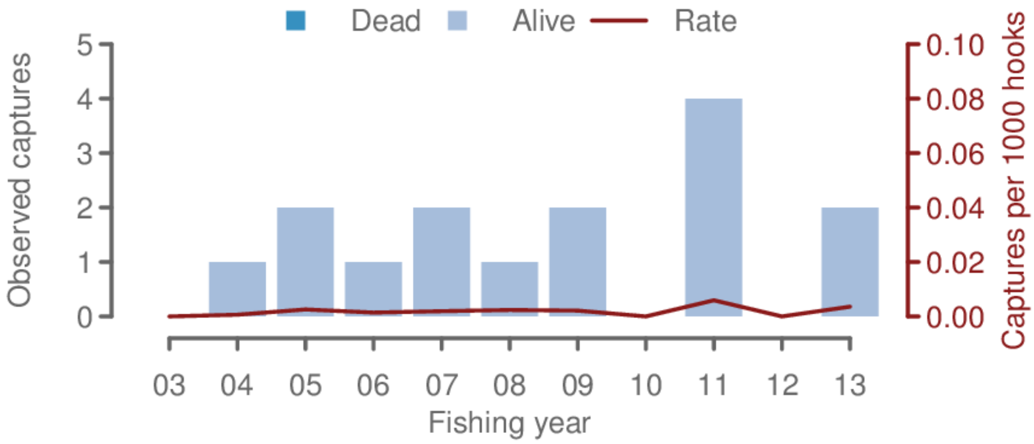


Figure 12: Observed captures of sea turtles in the New Zealand surface longline fisheries from 2002–03 to 2012–13.

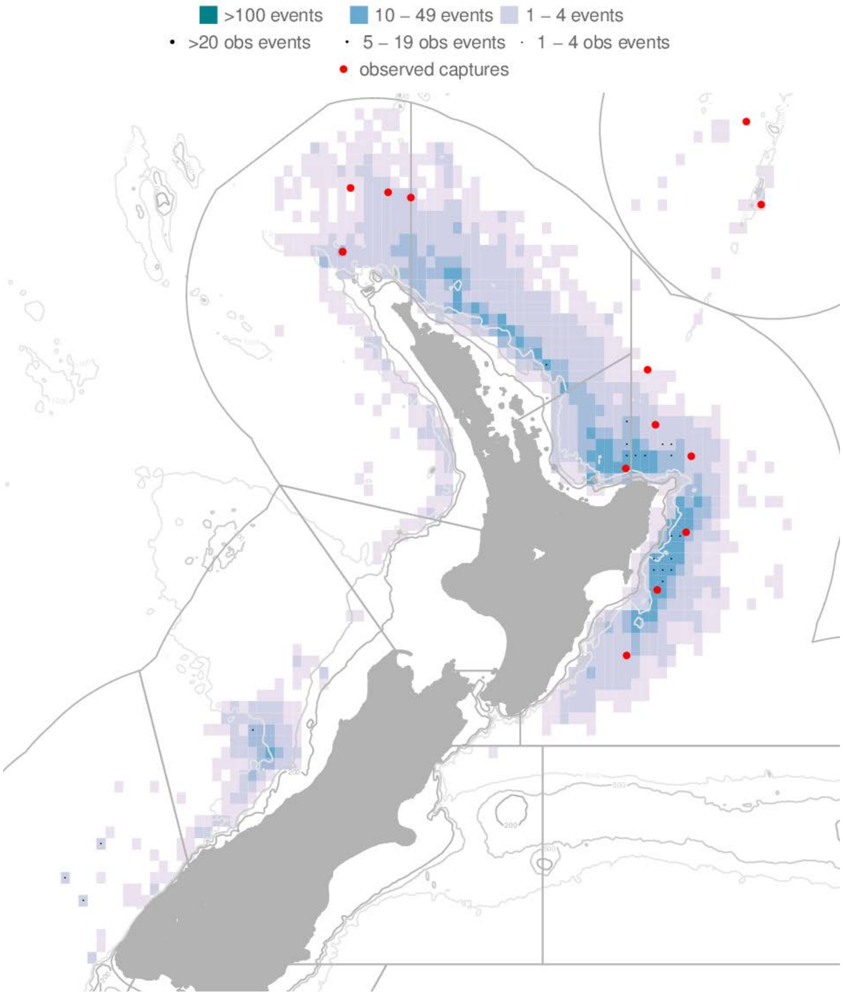


Figure 13: Distribution of fishing effort in the New Zealand surface longline fisheries and observed sea turtle captures, 2002–03 to 2012–13. Fishing effort is mapped into 0.2-degree cells, with the colour of each cell being related to the amount of effort. Observed fishing events are indicated by black dots, and observed captures are indicated by red dots. Fishing is only shown if the effort could be assigned a latitude and longitude, and if there were three or more vessels fishing within a cell. In this case, 89.4% of the effort is shown. See glossary for areas used for summarising the fishing effort and protected species captures.

4.2.3 Marine Mammals

4.2.3.1 Cetaceans

Cetaceans are dispersed throughout New Zealand waters (Perrin et al 2008). The spatial and temporal overlap of commercial fishing grounds and cetacean foraging areas has resulted in cetacean captures in fishing gear (Abraham & Thompson 2009, 2011).

Between 2002–03 and 2012–13, there were seven observed captures of whales and dolphins in surface longline fisheries. Observed captures included 5 unidentified cetaceans and 2 long-finned Pilot whales (Tables 11 and 12, Figure 14) (Thompson et al 2013). All captured animals recorded were documented as being caught and released alive (Thompson et al 2013). Cetacean capture distributions are more frequent off the east coast of the North Island (Figure 15)

Table 11: Number of observed cetacean captures in the New Zealand surface longline fisheries, 2002–03 to 2012–13, by species and area. Data from Thompson et al (2013), retrieved from http://data.dragonfly.co.nz/psc/. See glossary above for a description of the areas used for summarising the fishing effort and protected species captures.

Species	Bay of Plenty	East Coast North Island	Fiordland	Northland and Hauraki	West Coast North Island	West Coast South Island	Total
Long-finned pilot whale	0	1	0	0	0	1	2
Unidentified cetacean	1	1	1	1	1	0	5
Total	1	2	1	1	1	1	7

Table 12: Effort and captures of cetaceans in surface longline fisheries by fishing year. For each fishing year, the table gives the total number of hooks; the number of observed hooks; observer coverage (the percentage of hooks that were observed); the number of observed captures (both dead and alive); and the capture rate (captures per thousand hooks). For more information on the methods used to prepare the data, see Thompson et al (2013).

	Fishing effort			Observed captures	
Fishing year	All hooks	Observed hooks	% observed	Number	Rate
2002–2003	10 772 188	2 195 152	20.4	1	0
2003–2004	7 386 329	1 607 304	21.8	4	0.002
2004–2005	3 679 765	783 812	21.3	1	0.001
2005–2006	3 690 119	705 945	19.1	0	0
2006–2007	3 739 912	1 040 948	27.8	0	0
2007–2008	2 246 189	421 900	18.8	1	0.002
2008–2009	3 115 633	937 496	30.1	0	0
2009–2010	2 995 264	665 883	22.2	0	0
2010–2011	3 187 879	674 572	21.2	0	0
2011–2012	3 100 277	728 190	23.5	0	0
2012–13	2 862 182	560 333	19.6	0	0

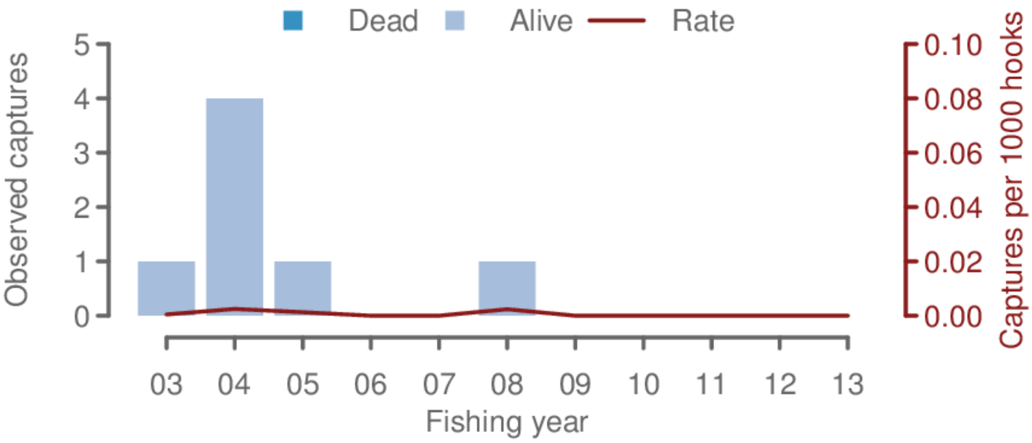


Figure 14: Observed captures of cetaceans in the New Zealand surface longline fisheries from 2002–03 to 2012–13.

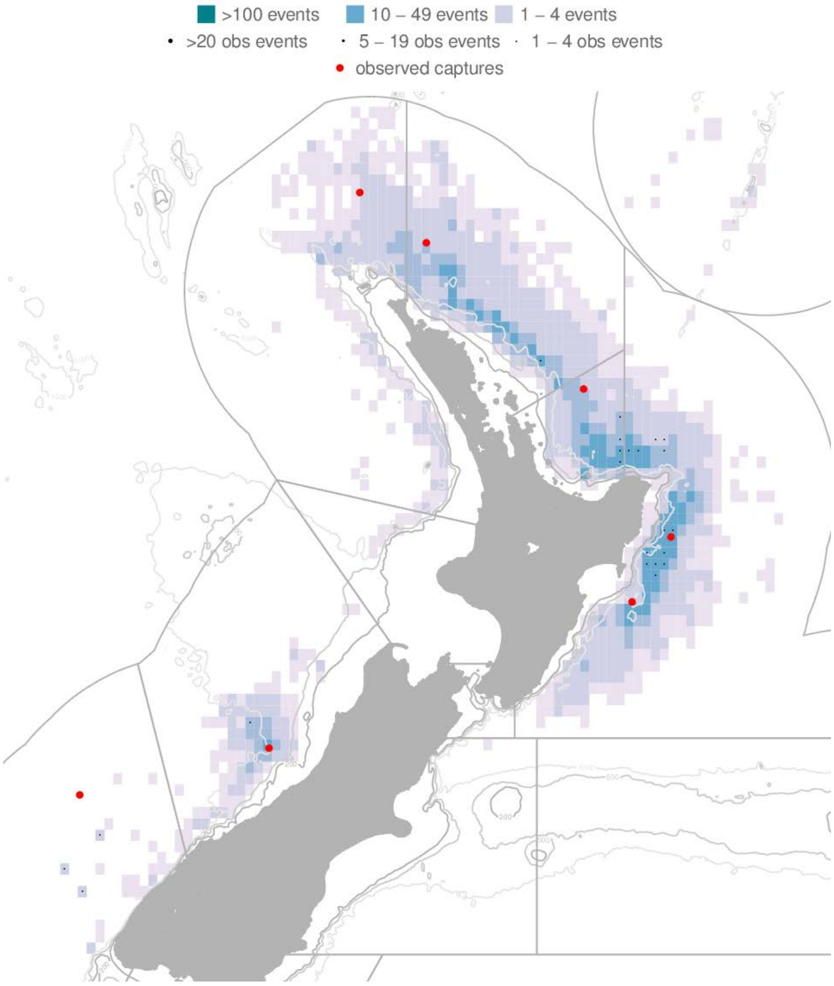


Figure 15: Distribution of fishing effort in the New Zealand surface longline fisheries and observed cetacean captures, 2002–03 to 2012–13. Fishing effort is mapped into 0.2-degree cells, with the colour of each cell being related to the amount of effort. Observed fishing events are indicated by black dots, and observed captures are indicated by red dots. Fishing is only shown if the effort could be assigned a latitude and longitude, and if there were three or more vessels fishing within a cell. In this case, 89.4% of the effort is shown. See glossary for areas used for summarising the fishing effort and protected species captures.

4.2.3.2 New Zealand fur seal bycatch

Currently, New Zealand fur seals are dispersed throughout New Zealand waters, especially in waters south of about 40º S to Macquarie Island. The spatial and temporal overlap of commercial fishing grounds and New Zealand fur seal foraging areas has resulted in New Zealand fur seal captures in fishing gear (Mattlin 1987, Rowe 2009). Most fisheries with observed captures occur in waters over or close to the continental shelf, which slopes steeply to deeper waters relatively close to shore, and thus rookeries and haulouts, around much of the South Island and offshore islands. Captures on longlines occur when the fur seals attempt to feed on the bait and fish catch during hauling. Most New Zealand fur seals are released alive, typically with a hook and short snood or trace still attached.

New Zealand fur seal captures in surface longline fisheries have been generally observed in waters south and west of Fiordland, but also in the Bay of Plenty-East Cape area when the animals have attempted to take bait or fish from the line as it is hauled. These capture rates include animals that are released alive (100% of observed surface longline capture in 2008–09; Thompson & Abraham 2010). Capture rates in 2011–12 and 2012-13 were higher than they were in the early 2000s (Figures 16 and 17). While fur seal captures have occurred throughout the

range of this fishery most New Zealand captures have occurred off the Southwest coast of the South Island (Figure 18). Between 2002–03 and 2012–13, there were 267 observed captures of New Zealand fur seal in surface longline fisheries (Tables 13 and 14).

Table 13: Number of observed New Zealand fur seal captures in the New Zealand surface longline fisheries, 2002–03 to 2012–13, by species and area. Data from Thompson et al (2013), retrieved from http://data.dragonfly.co.nz/psc/. See glossary above for a description of the areas used for summarising the fishing effort and protected species captures.

	Bay of Plenty	East Coast North Island	Fiordland	Northland and Hauraki	Stewart Snares Shelf	West Coast North Island	West Coast South Island	Total
New Zealand fur seal	11	33	179	4	4	2	34	267

Table 14: Effort and captures of New Zealand fur seal in the New Zealand surface longline fisheries by fishing year. For each fishing year, the table gives the total number of hooks; the number of observed hooks; observer coverage (the percentage of hooks that were observed); the number of observed captures (both dead and alive); and the capture rate (captures per thousand hooks). Data from Thompson et al (2013), retrieved from http://data.dragonfly.co.nz/psc/. Estimates from 2002–03 to 2010–11 and preliminary estimates for 2012–13 are based on data version 20140131.

	Fishing effort			Observed captures		Estimated captures	
Fishing year	All hooks	Observed hooks	% observed	Number	Rate	Mean	95% c.i.
2002–2003	10 772 188	2 195 152	20.4	56	0.026	299	199–428
2003–2004	7 386 329	1 607 304	21.8	40	0.025	134	90–188
2004–2005	3 679 765	783 812	21.3	20	0.026	66	38–99
2005–2006	3 690 119	705 945	19.1	12	0.017	47	23–79
2006–2007	3 739 912	1 040 948	27.8	10	0.010	32	14–55
2007–2008	2 246 189	421 900	18.8	10	0.024	40	19–68
2008–2009	3 115 633	937 496	30.1	22	0.023	53	29–81
2009–2010	2 995 264	665 883	22.2	19	0.029	77	43–121
2010–2011	3 187 879	674 572	21.2	17	0.025	64	35–101
2011–2012	3 100 277	728 190	23.5	40	0.055	140	92–198
2012–2013†	2 862 182	560 333	19.6	21	0.037	110	65–171

†Provisional data, model estimates not finalised.

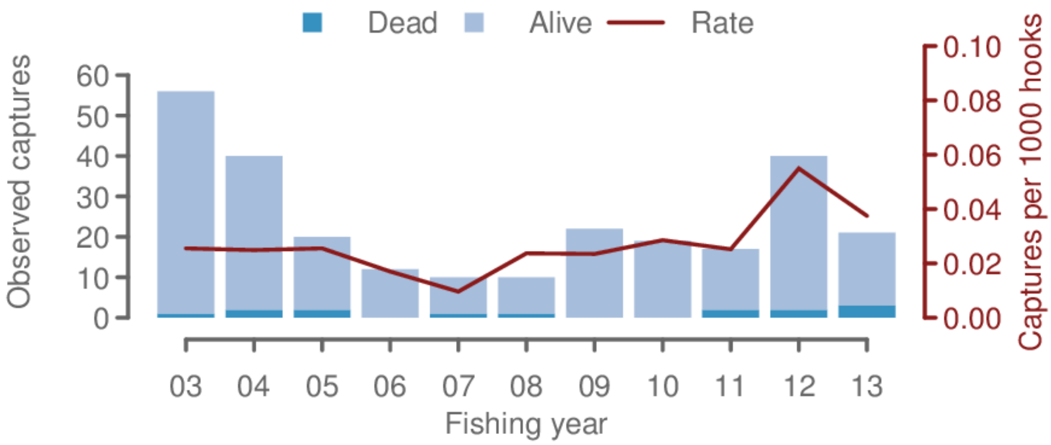


Figure 16: Observed captures of New Zealand fur seal in the New Zealand surface longline fisheries from 2002–03 to 2012–13.

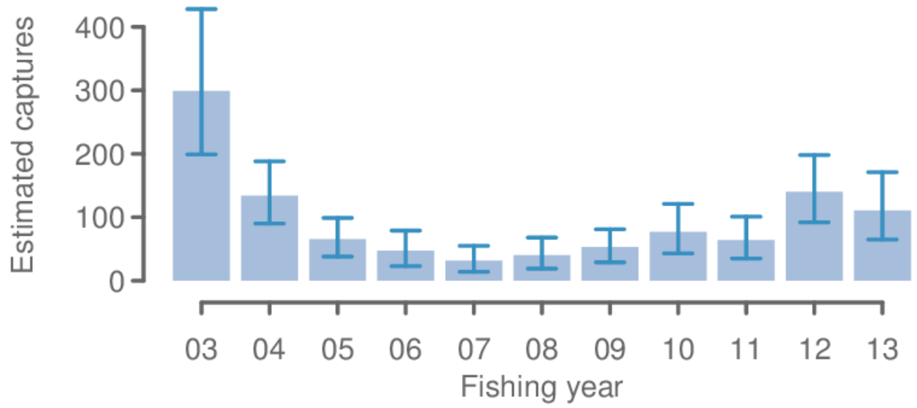


Figure 17: Estimated captures of New Zealand fur seal in the New Zealand surface longline fisheries from 2002–03 to 2012–13.

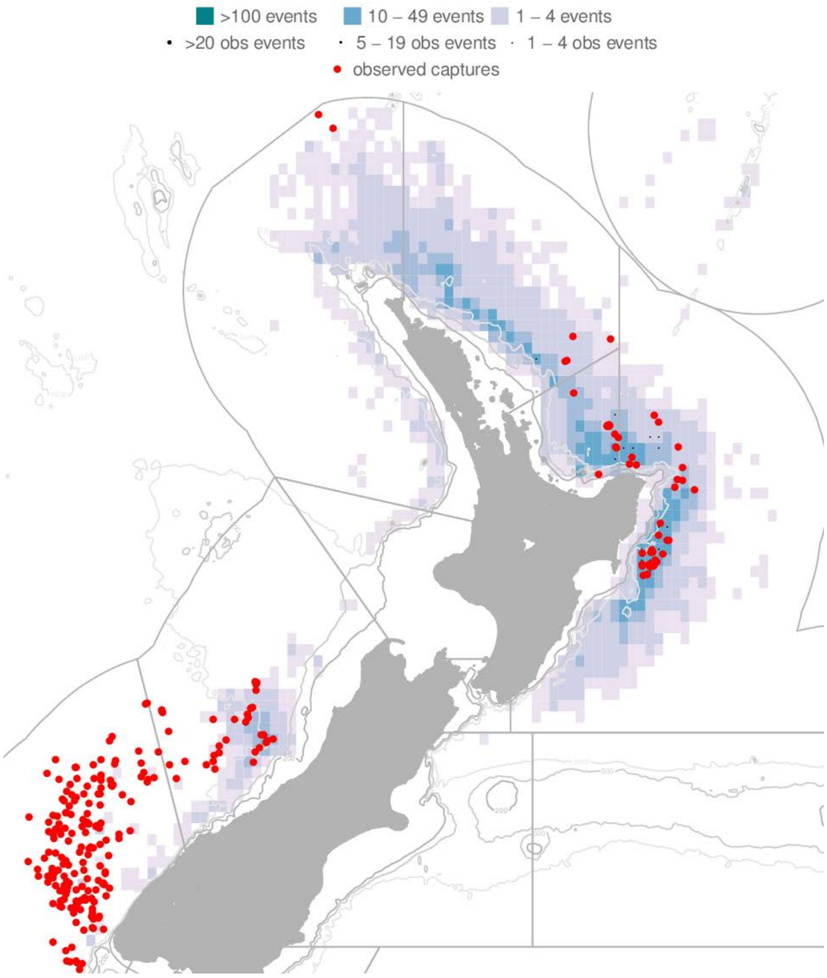


Figure 18: Distribution of fishing effort in the New Zealand surface longline fisheries and observed New Zealand fur seal captures, 2002–03 to 2012–13. Fishing effort is mapped into 0.2-degree cells, with the colour of each cell being related to the amount of effort. Observed fishing events are indicated by black dots, and observed captures are indicated by red dots. Fishing is only shown if the effort could be assigned a latitude and longitude, and if there were three or more vessels fishing within a cell. In this case, 89.4% of the effort is shown. See glossary for areas used for summarising the fishing effort and protected species captures.

4.3 Incidental fish bycatch

Observer records indicate that a wide range of species are landed by the longline fleets in New Zealand fishery waters. Blue sharks are the most commonly landed species (by number), followed by Ray's bream (Table 15). Southern bluefin tuna and albacore tuna are the only target species that occur in the top five of the frequency of occurrence.

Table 15: Total estimated catch (numbers of fish) of common bycatch species in the New Zealand longline fishery as estimated from observer data from 2009 to 2013. Also provided is the percentage of these species retained (2013 data only) and the percentage of fish that were alive when discarded, N/A (none discarded).

Species	2010	2011	2012	2013	% retained (2013)	discards % alive (2013)
Blue shark	66113	53432	132925	158736	45.2	97.4
Lancetfish	43425	37305	7866	19172	0.1	37.6
Rays bream	20041	18453	19918	13568	97.4	4.2
Porbeagle shark	4679	9929	7019	9805	34.0	79.8
Mako shark	4490	9770	3902	3981	35.5	84.9
Moonfish	5398	3418	2363	2470	99.0	0.0
Escolar	1539	6602	2181	2088	30.2	76.3
Sunfish	3148	3773	3265	1937	2.7	100.0
Pelagic stingray	1983	4090	712	1199	1.0	97.0
Butterfly tuna	1158	909	713	1030	48.1	11.1
Deepwater dogfish	377	548	647	743	1.2	88.5
Oilfish	886	1747	509	386	26.5	72.2
Rudderfish	326	338	491	362	13.0	80.0
Thresher shark	209	349	246	256	33.3	75.0
Skipjack tuna	91	255	123	240	100.0	N/A
Dealfish	1160	223	372	237	1.7	25.1
Striped marlin	471	175	124	182	0.0	44.4
Big scale pomfret	505	139	108	67	88.2	100.0
School shark	62	49	477	21	100.0	N/A

4.4 Benthic interactions

N/A

4.5 Key environmental and ecosystem information gaps

Cryptic mortality is unknown at present.

Observer coverage in the New Zealand fleet has historically not been spatially or temporally representative of the fishing effort. However in 2013 the observer effort was re-structured to rectify this by planning observer deployment to correspond with recent spatial and temporal trends in fishing effort.

5. STOCK ASSESSMENT

With the establishment of the WCPFC in 2004, future stock assessments of the western and central Pacific Ocean stock of mako shark will be reviewed by the WCPFC. There is currently a shark research plan that has been developed within the context of the Western and Central Pacific Fisheries Commission but mako sharks will not be a focus of that plan in the near future.

There have been no stock assessments of mako sharks in New Zealand, or elsewhere in the world. No estimates of yield are possible with the currently available data.

Indicator analyses (Figure 19 and 20) suggest that mako shark populations in the New Zealand EEZ have not been declining under recent fishing pressure, and may have been increasing since 2005 (Table 15, Francis et al. 2014). These changes are presumably in response to a decline in SLL fishing effort since 2002 (Griggs & Baird 2013), and declines in annual landings since a peak in 2000-01 for mako sharks. Observer data from 1995 suggest that mako sharks may have undergone a down-then-up trajectory. The quality of observer data and model fits means these interpretations are uncertain. The stock status of mako sharks may be recovering. Conclusive determinations of stock status will require regional (i.e. South Pacific) stock assessments.

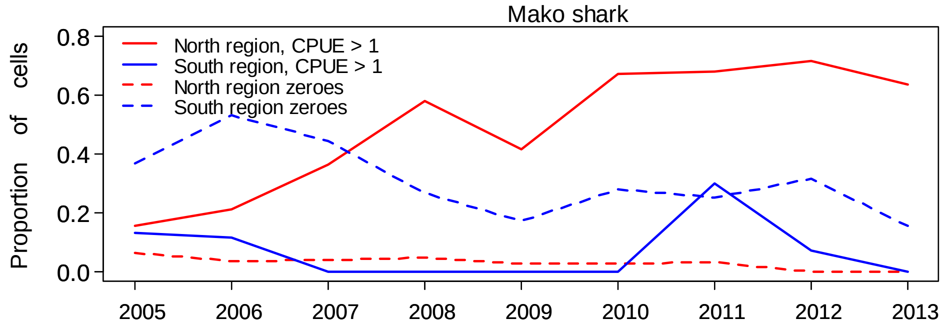


Figure 19. Mako shark distribution indicators. Proportions of 0.5 degree rectangles having CPUE greater than 1 per 1000 hooks, and proportions of rectangles having zero catches, for North and South regions by fishing year, based on estimated catches (processed and discarded combined) reported on TLCERs. Source: Francis et al. (2014). North region comprises Fisheries Management Areas (FMAs) 1, 2, 8, and 9, and South region comprises FMAs 5 and 7.

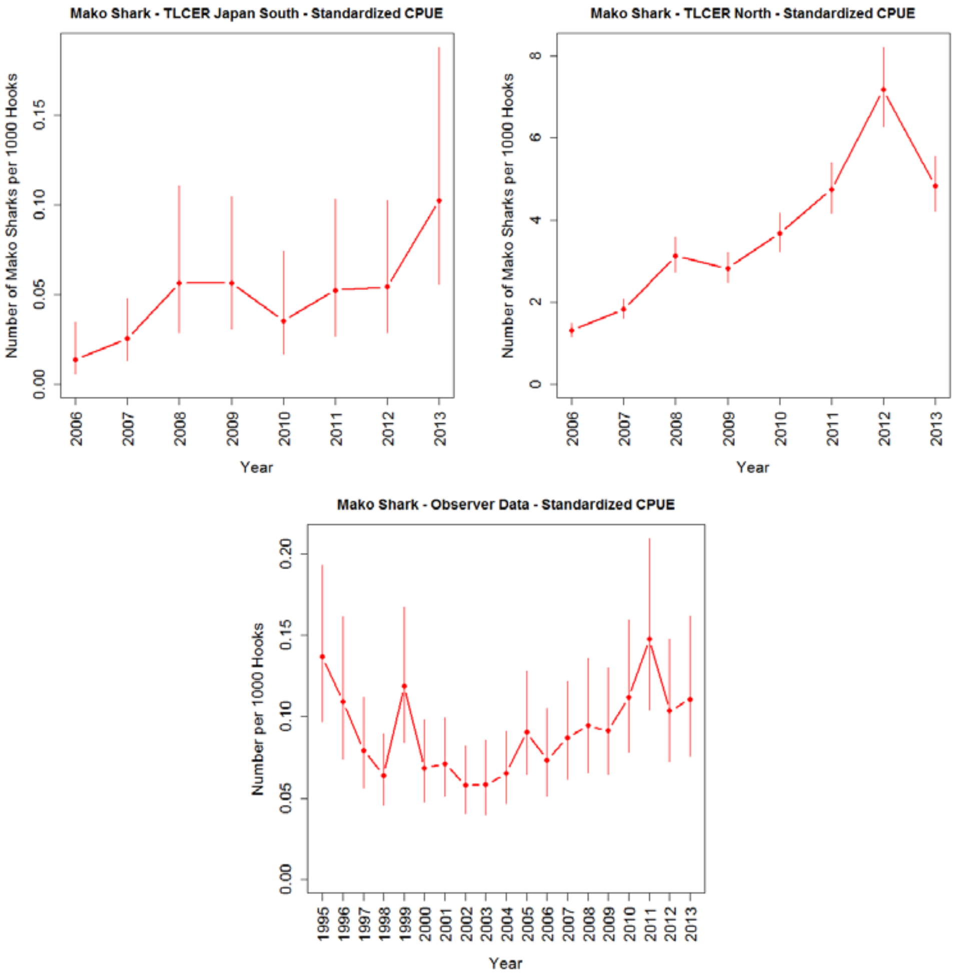


Figure 20. Standardised CPUE indices for commercial TLCER (Japan South and North) and observer datasets (all New Zealand).

Table 15: Summary of trends identified in abundance indicators since the 2005 fishing year based on both TLCER and observer data sets. The CPUE-Obs indicator was calculated for both North and South regions combined. North region comprises Fisheries Management Areas (FMAs) 1, 2, 8, and 9, and South region comprises FMAs 5 and 7. For the CPUE-TLCER indicator in South region, only the Japan dataset indicator is shown (the TLCER Domestic South dataset was small and probably unrepresentative). Green cells show indicators that suggest positive trends in stock size. Note that a downward trend in 'proportion-zeroes' is considered a positive stock trend. NA = indicator not applicable because of small sample size. Source: Francis et al. (2014).

		North region			South region		
Indicator class	Indicator	Blue	Porbeagle	Mako	Blue	Porbeagle	Mako
Distribution	High-CPUE	Up	Up	Up	Up	Up	NA
Distribution	Proportion-zeroes	Nil	Down	Down	Nil	Nil	Down
Catch composition	GM index total catch - TLCER	Up (all species)			Up (all species)		
Catch composition	GM index total catch - Obs	Up (all species)			Nil (all species)		
Catch composition	GM index HMS shark catch - TLCER	Up (all species)			Up (all species)		
Catch composition	GM index HMS shark catch - Obs	Up (all species)			Nil (all species)		
Standardised CPUE	CPUE - TLCER	Up	Nil	Up	Up	Nil	Nil
Standardised CPUE	CPUE - Obs	Up	Nil	Nil	Up	Nil	Nil
Sex ratio	Proportion males	Nil	Nil	Nil	Nil	Nil	NA
Size composition	Median length - Males	Nil	Nil	Nil	Nil	Nil	NA
Size composition	Median length - Females	Nil	Nil	Nil	Nil	Nil	NA

Compared with a wide range of shark species, the productivity of mako sharks is very low. Females have a high age-at-maturity, moderately high longevity (and therefore low natural mortality rate) and low annual fecundity. The low fecundity is cause for serious concern, as the ability of the population to replace sharks removed by fishing is very limited.

Observer records show that few mako sharks were observed in the South. The distributions were roughly bimodal with a wide size range and no discernible difference between males and females (Figure 21). There were more females than males. With mean length of maturity of 182.5 cm FL for males and 280 cm fork length for females (Francis & Duffy 2005), most mako sharks were immature (85.1% of males and 100.0% of females, overall) (Griggs & Baird 2013).

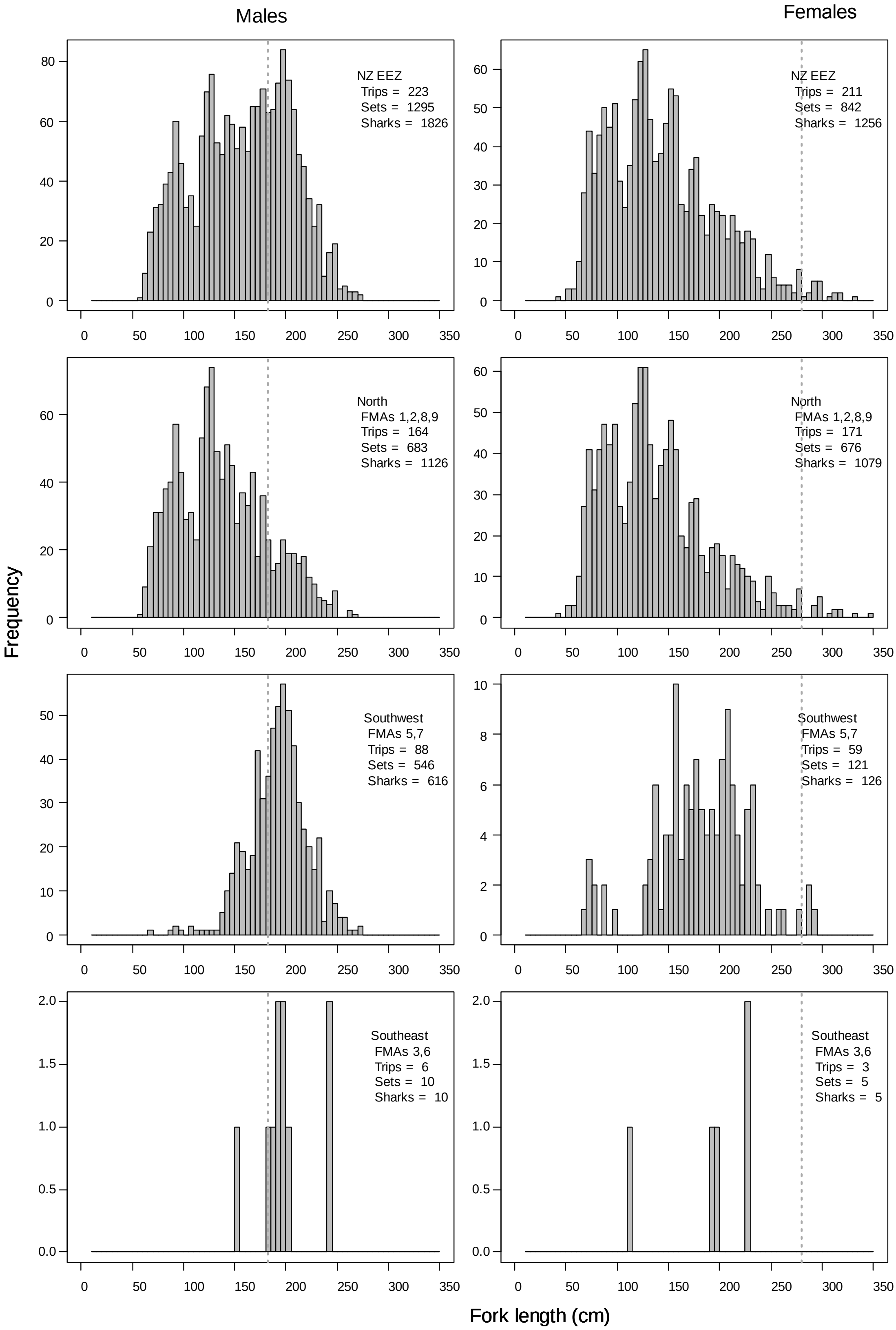


Figure 21: Length-frequency distributions of male and female mako sharks measured by observers aboard surface longline vessels between 1993 and 2012 for the New Zealand EEZ, and North, Southwest and Southeast regions. The dashed vertical lines indicate the median length at maturity. Francis (2013).

6. STATUS OF THE STOCK

Stock structure assumptions

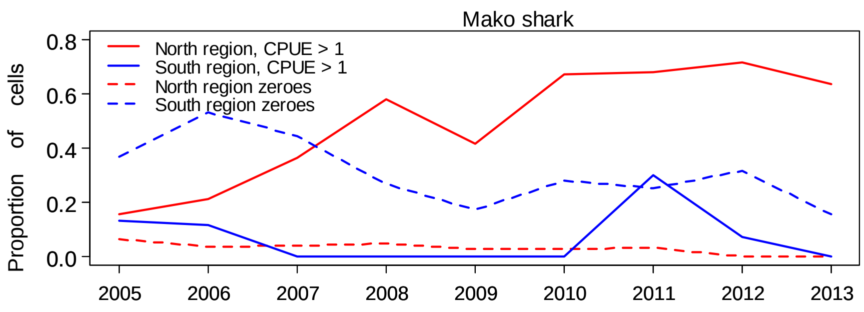
MAK 1 is assumed to be part of the wider South Western Pacific Ocean stock. However, there is no stock assessment for this wider stock. The results below are from indicator analyses of the New Zealand component of that stock only. but the assessment below relates only to the New Zealand component of that stock.

Stock Status	
Year of Most Recent Assessment	2014
Assessment Runs Presented	Indictor analyses for NZ EEZ only
Reference Points	Target: Not established Soft Limit: Not established but HSS default of 20% SB_0 assumed Hard Limit: Not established but HSS default of 10% SB_0 assumed Overfishing threshold: F_{MSY}
Status in relation to Target	Unknown
Status in relation to Limits	Unknown
Status in relation to Overfishing	Unknown

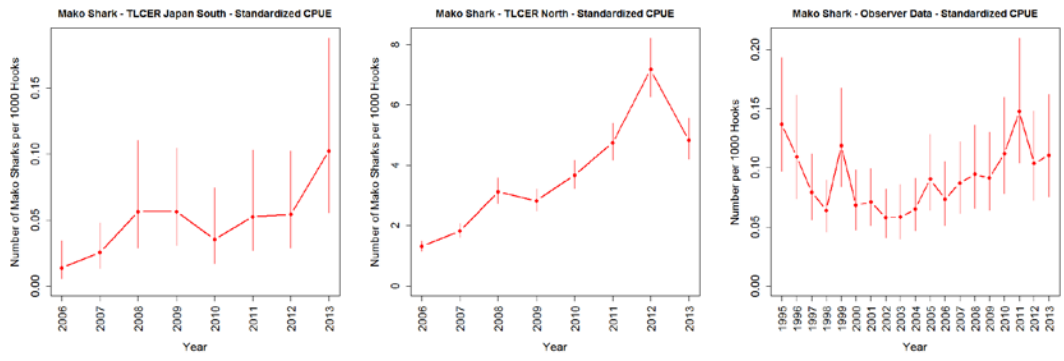
Historical Stock Status Trajectory and Current Status

Summary of trends identified in abundance indicators since the 2005 fishing year based on both TLCER and observer data sets. North region comprises Fisheries Management Areas (FMAs) 1, 2, 8, and 9, and South region comprises FMAs 5 and 7.

		North region			South region		
Indicator class	Indicator	Blue	Porbeagle	Mako	Blue	Porbeagle	Mako
Distribution	High-CPUE	Up	Up	Up	Up	Up	NA
Distribution	Proportion-zeroes	Nil	Down	Down	Nil	Nil	Down
Catch composition	GM index total catch - TLCER	Up (all species)			Up (all species)		
Catch composition	GM index total catch - Obs	Up (all species)			Nil (all species)		
Catch composition	GM index HMS shark catch - TLCER	Up (all species)			Up (all species)		
Catch composition	GM index HMS shark catch - Obs	Up (all species)			Nil (all species)		
Standardised CPUE	CPUE - TLCER	Up	Nil	Up	Up	Nil	Nil
Standardised CPUE	CPUE - Obs	Up	Nil	Nil	Up	Nil	Nil
Sex ratio	Proportion males	Nil	Nil	Nil	Nil	Nil	NA
Size composition	Median length - Males	Nil	Nil	Nil	Nil	Nil	NA
Size composition	Median length - Females	Nil	Nil	Nil	Nil	Nil	NA



Mako shark distribution indicators. Proportions of 0.5 degree rectangles having CPUE greater than 1 per 1000 hooks, and proportions of rectangles having zero catches, for North and South regions by fishing year, based on estimated catches (processed and discarded combined) reported on TLCERs. Source: Francis et al. (2014). North region comprises Fisheries Management Areas (FMAs) 1, 2, 8, and 9, and South region comprises FMAs 5 and 7.



Standardised CPUE indices for commercial TLCER (Japan South and North) and observer datasets (all New Zealand).

Fishery and Stock Trends	
Recent Trend in Biomass or Proxy	Appears to be increasing
Recent Trend in Fishing Intensity or Proxy	Appears to be decreasing
Other Abundance Indices	-
Trends in Other Relevant Indicator or Variables	Catches in New Zealand increased from the early 1980s to a peak in the early 2000s but have declined from highs of 319 t to 74-103 t in between 2005-06 and 2012-13. This decline in catch coincides with a decline in longline fishing effort.

Projections and Prognosis		
Stock Projections or Prognosis	The stock is likely to increase if effort remains at current levels	
Probability of Current Catch or TACC causing Biomass to remain below or to decline below Limits	Soft Limit: Unknown Hard Limit: Unknown	
Probability of Current Catch or TACC causing Overfishing to continue or to commence	Unknown	
Assessment Methodology and Evaluation		
Assessment Type	Level 2- Partial Quantitative Stock Assessment: Standardised CPUE indices and other fishery indicators	
Assessment Method	Indicator analyses	
Assessment Dates	Latest assessment: 2014	Next assessment: Unknown
Overall assessment quality rank	1 – High Quality	
Main data inputs (rank)	- Distribution - Species composition - Size and sex ratio - Catch per unit effort	1 – High quality
Data not used (rank)	N/A	
Changes to Model Structure and Assumptions	-	
Major Sources of Uncertainty	Catch recording before 2005 may not be accurate	
Qualifying Comments		
-		

Fishery Interactions
Interactions with protected species are known to occur in the longline fisheries of the South Pacific, particularly south of 25°S. Seabird bycatch mitigation measures are required in the New Zealand and Australian EEZ's and through the WCPFC Conservation and Management Measure CMM2007-04. Sea turtles are also incidentally captured in longline gear; the WCPFC is attempting to reduce sea turtle interactions through Conservation and Management Measure CMM2008-03.

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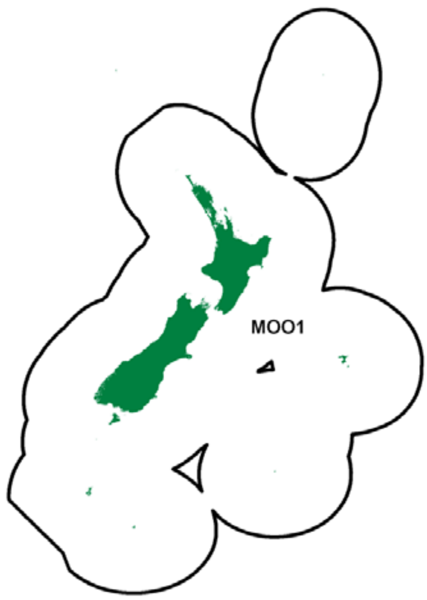
MOONFISH (MOO)

(Lampris guttatus)



1. FISHERY SUMMARY

Moonfish were introduced into the QMS on 1 October 2004 under a single QMA, MOO 1, with the TAC equal to the TACC (Table 1).

Table 1: Recreational and Customary non-commercial allowances, TACCs and TACs (all in tonnes) of moonfish.

Fishstock	Recreational Allowance (t)	Customary non-commercial Allowance (t)	Other mortality (t)	TACC (t)	TAC (t)
MOO 1	0	0	0	527	527

Moonfish were added to the Third Schedule of the 1996 Fisheries Act with a TAC set under s14.

1.1 Commercial fisheries

Most moonfish (70%) are caught as bycatch in surface longlines fisheries (the eighth most common bycatch species in the surface longline fishery; table 13). The main fisheries catching moonfish by surface longlining are targeting bigeye tuna (*Thunnus obesus*) and, to a lesser extent, southern bluefin tuna (*T. maccoyii*), albacore (*T. alalunga*) and yellowfin tuna (*T. albacares*). Mid-water trawling accounts for 18% of the catch, bottom trawling 8% and bottom longlining 1%. The main target fisheries using mid-water trawling are for southern blue whiting (*Micromesistius australis*) and hoki (*Macruronus novaezelandiae*), and bottom trawling for hoki and gemfish (*Rexea solandri*).

When caught on tuna longlines most moonfish are alive (79.8%). Most moonfish catch is kept and landed, as there is a market demand. It is likely that landing data for moonfish reasonably represents actual catches, although it may include small amounts (less than 1%) of the less common *Lampris* spp. and the more southerly occurring species (*Lampris immaculatus*) because of misidentification. Most of the catch taken by the tuna longline fishery was aged 2 to 14 years, and most (71%) of the commercial catch appears to be of adult fish. Figure 1 shows the historic landings and longline fishing effort for moonfish inside and outside the New Zealand EEZ.

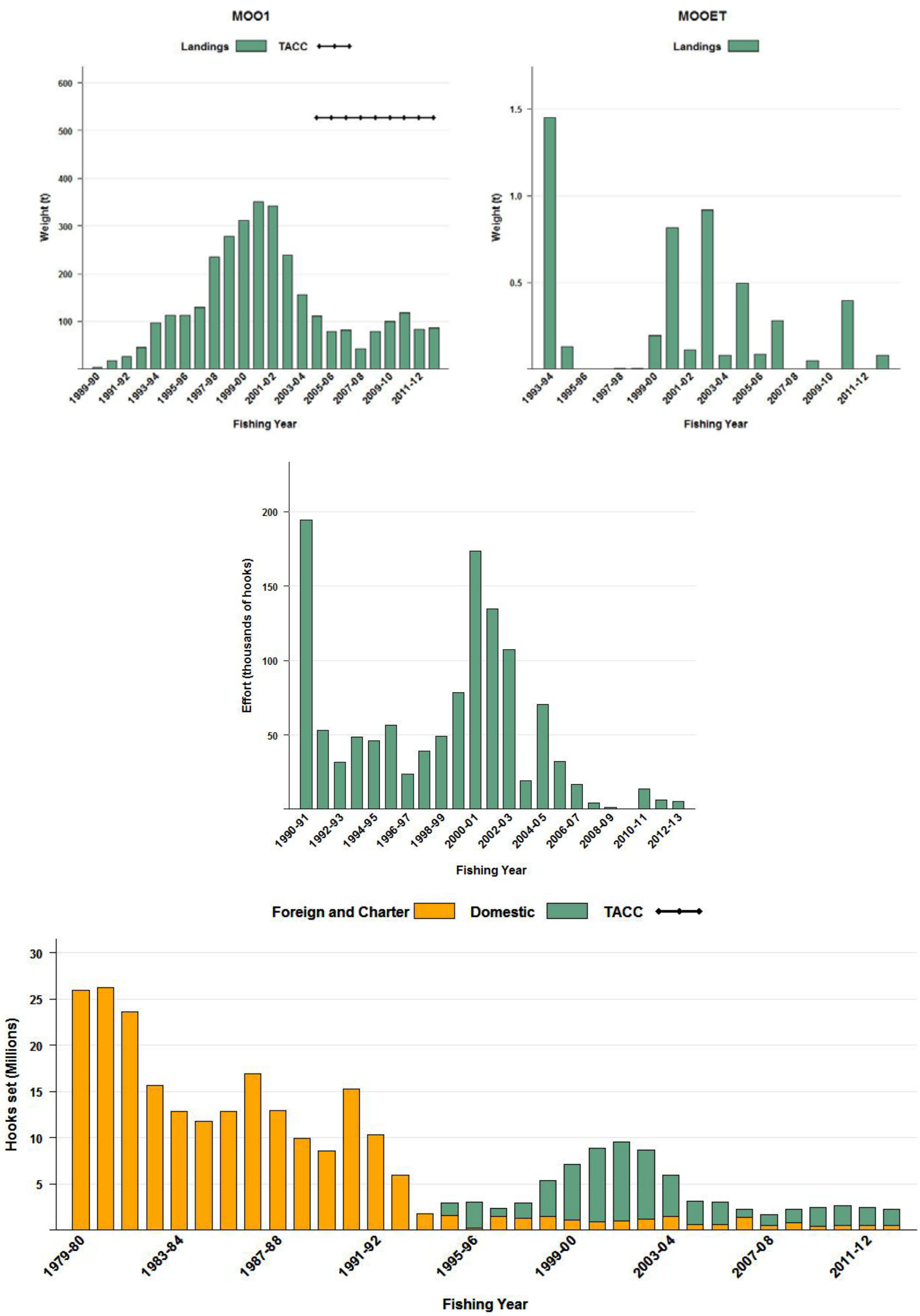


Figure 1: [Top] Moonfish catch from 1989–90 to 2012–13 within New Zealand waters (MOO 1) and 1993–94 to 2012–13 on the high seas (MOO ET). [Middle] Fishing effort (number of hooks set) for all high seas New Zealand flagged surface longline vessels from 1990–91 to 2012–13. [Bottom] Fishing effort (number of hooks set) within New Zealand EEZ for domestic and foreign vessels (including foreign vessels chartered by New Zealand fishing companies), from 1979–80 to 2012–13.

Reported landings in New Zealand increased each year from 3 t in 1989–90 to a maximum of 351 t in 2000–01, but have declined since then as a result of decreasing effort in the surface longline fishery (Table 2). From 2005–06 to 2011–12 landings have averaged around 84 t. New Zealand landings of moonfish appear to represent about 70% of the reported catch of moonfish in the wider South Pacific area based on Food and Agriculture Organisation of the United Nations statistics. However, this may reflect general non-reporting of bycatch.

Table 2: Reported landings (t) of moonfish (CELR, CLR and LFRR data from 1989–90 to 2000–01, MHR data from 2001–02 onwards).

Fishing year	MOO 1 (all FMAs)
1989–90	3
1990–91	18
1991–92	26
1992–93	46
1993–94	97
1994–95	112
1995–96	112
1996–97	130
1997–98	234
1998–99	278
1999–00	311
2000–01	351
2001–02	342
2002–03	239
2003–04	156
2004–05	112
2005–06	80
2006–07	82
2007–08	43
2008–09	80
2009–10	100
2010–11	118
2011–12	84
2012–13	85

The majority of moonfish are caught in the bigeye tuna (77%) and southern bluefin tuna (13%) surface longline fisheries (Figure 2). Across all longline fisheries albacore make up the bulk of the catch (32%) (Figure 3). Longline fishing effort is distributed along the east coast of the North Island and the south west coast of the South Island. The west coast South Island fishery predominantly targets southern bluefin tuna, whereas the east coast of the North Island targets a range of species including bigeye, swordfish, and southern bluefin tuna (Figure 4).

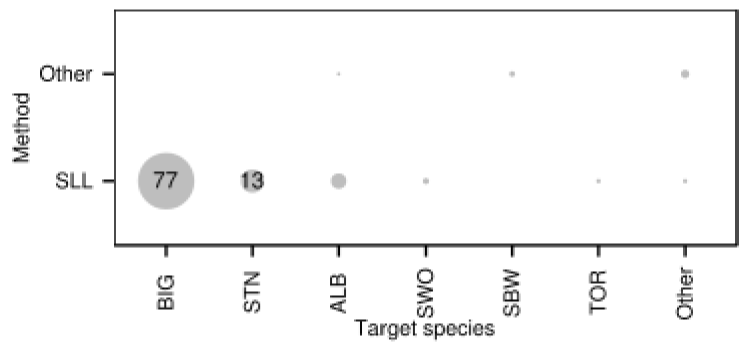


Figure 2: A summary of the proportion of landings of moonfish taken by each target fishery and fishing method. The area of each circle is proportional to the percentage of landings taken using each combination of fishing method and target species. The number in the circle is the percentage. SLL = surface longline (Bentley et al 2013).

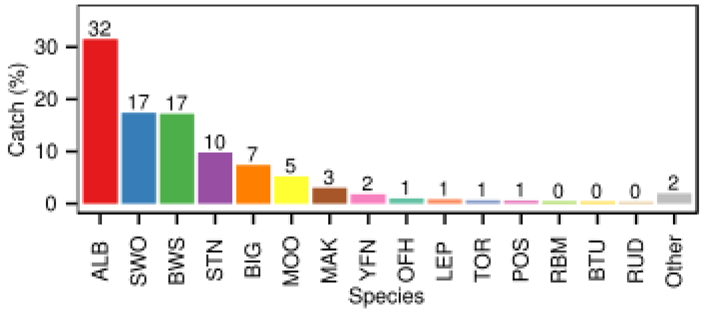


Figure 3: A summary of species composition of the reported surface longline catch. The percentage by weight of each species is calculated for all surface longline trips (Bentley et al 2013).

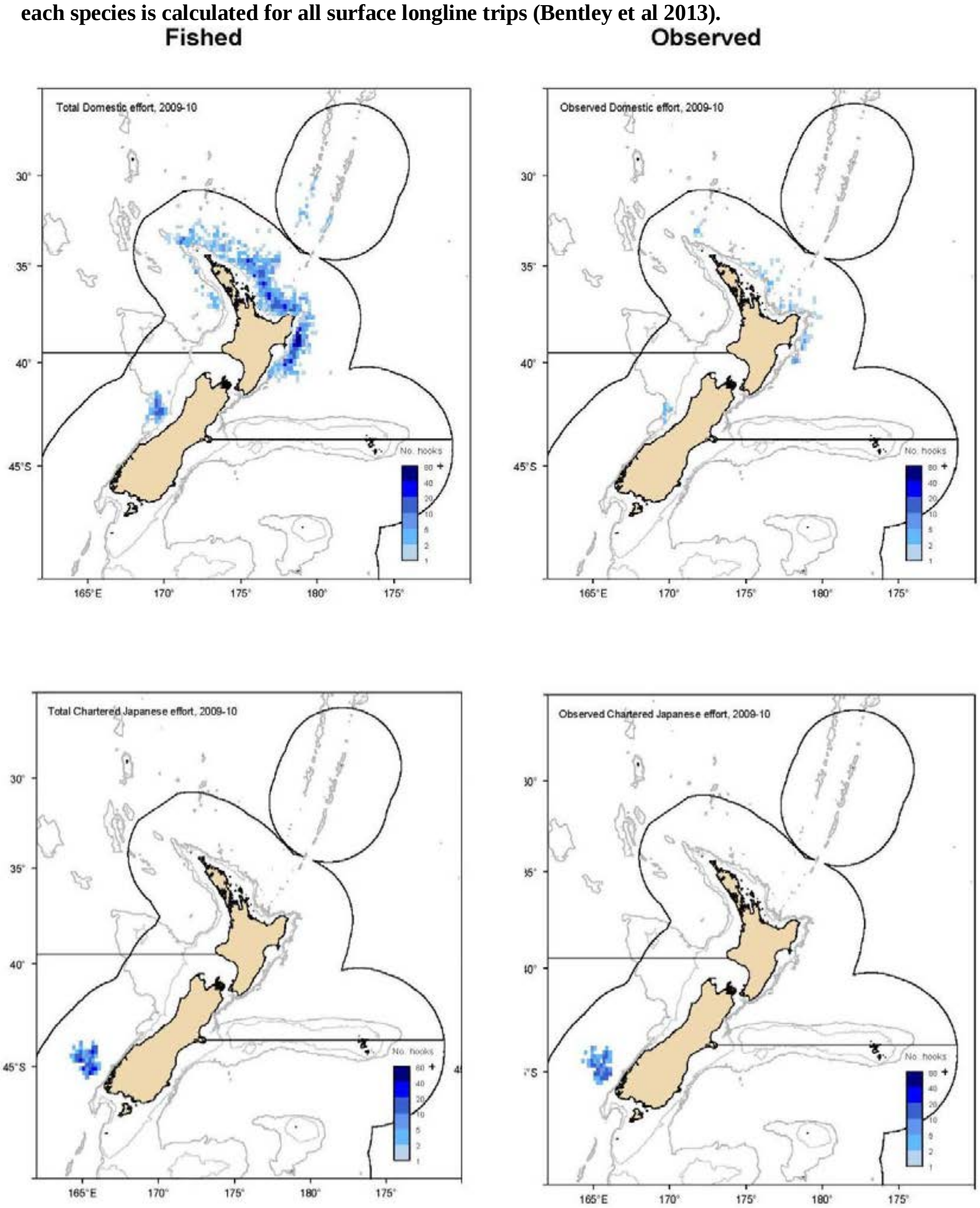


Figure 4: Distribution of fishing positions for domestic (top two panels) and charter (bottom two panels) vessels, for the 2009–10 fishing year, displaying both fishing effort (left) and observed effort (right).

Across all fleets in the longline fishery 79.8% of the moonfish were alive when brought to the side of the vessel (Table 3). The domestic fleets retain around 96.5–100% of their moonfish catch, while the foreign charter fleets retain a slightly lower percentage range (92–100%) of moonfish, the Australian fleet that fished in New Zealand waters in 2006–07 retained 100% of their moonfish catch (Table 4).

Table 3: Percentage of moonfish (including discards) that were alive or dead when arriving at the longline vessel and observed during 2006–07 to 2009–10, by fishing year, fleet and region. Small sample sizes (number observed < 20) were omitted (Griggs & Baird 2013).

Species	Year	Fleet	Area	alive	% dead	Number
Moonfish	**2006–07**	Australia	North	80.0	20.0	20
		Charter	North	85.2	14.8	472
			South	84.2	15.8	114
		Domestic	North	65.6	34.4	180
		Total		**80.4**	**19.6**	**786**
	2007–08	Charter	South	100.0	0.0	41
		Domestic	North	78.4	21.6	97
		Total		**84.8**	**15.2**	**138**
	2008–09	Charter	North	100.0	0.0	60
			South	100.0	0.0	30
		Domestic	North	72.6	27.4	201
		Total		**81.1**	**18.9**	**291**
	2009–10	Charter	South	98.6	1.4	69
		Domestic	North	71.5	28.5	333
		Total		**76.0**	**24.0**	**408**
	Total all strata			**79.8**	**20.2**	**1 623**

Table 4: Percentage of moonfish that were retained, or discarded or lost, when observed on a longline vessel during 2006–07 to 2009–10, by fishing year and fleet. Small sample sizes (number observed < 20) omitted (Griggs & Baird 2013).

Year	Fleet	% retained	% discarded or lost	Number
2006–07	Australia	100.0	0.0	20
	Charter	91.6	8.4	616
	Domestic	97.2	2.8	180
	Total	**93.0**	**7.0**	**816**
2007–08	Charter	100.0	0.0	41
	Domestic	100.0	0.0	96
	Total	**100.0**	**0.0**	**137**
2008–09	Charter	100.0	0.0	107
	Domestic	98.5	1.5	201
	Total	**99.0**	**1.0**	**308**
2009–10	Charter	100.0	0.0	76
	Domestic	96.5	3.5	345
	Total	**97.1**	**2.9**	**421**
Total all strata		**95.7**	**4.3**	**1 682**

1.2 Recreational fisheries

There is no information on recreational catch levels of moonfish. Moonfish has not been recorded from recreational surveys conducted by the Ministry for Primary Industries (MPI).

1.3 Customary non-commercial fisheries

There is no information on customary catch, although customary fishers consider moonfish good eating and may have used moonfish in the past.

1.4 Illegal catch

There is no known illegal catch of moonfish.

1.5 Other sources of mortality

There is no information on other sources of mortality although moonfish are occasional prey of blue and mako sharks in New Zealand waters, suggesting there may be some unobserved shark depredation of longline caught moonfish.

2. BIOLOGY

Until recently, little was known about the biology of moonfish in New Zealand waters. Studies have examined growth rates, natural mortality, and maturity for moonfish.

Age and growth of moonfish (*Lampris guttatus*) in New Zealand waters was assessed using counts of growth bands on cross sections of the second dorsal fin ray. MPI observers working on tuna longline vessels collected fin samples. Observers also collected maturity data, and length-frequency data were obtained from the longline observer database.

Thin sections were cut from fin rays 3.5–4 times the condyle width above the fin base. Sections were read blind (without knowing the fish length) by two readers. Readability scores were poor and the four readers who examined the fin rays came to two different interpretations.

Length-at-age data did not show any marked differences between males and females. Von Bertalanffy growth curves were fitted to the age estimates of both readers individually, and also to the mean ages of the two readers. The mean age provides the best available age estimate for moonfish samples. However, because of differences between readers, and the un-validated nature of the estimates, the growth curves must be interpreted with caution, especially for younger fish.

The growth curves suggest rapid early growth. The maximum age estimated in this study was 13 or 14 years depending on the reader, but this is probably an underestimate of true longevity. Using a maximum age of 14 years, Hoenig's method provides an *M* estimate of 0.30. If moonfish live to 20 years, this would reduce to 0.21. The Chapman-Robson estimate of *Z* is 0.13–0.14 for ages at recruitment of 2–4 years. However, the sample was not randomly selected and so this is probably unreliable. The best estimate of *M* may be around 0.20–0.25.

Length and age-at-maturity could not be accurately determined due to insufficient data, but it appears that fish longer than about 80 cm fork length are mature. The corresponding age-at-maturity would be 4.3 years. Sexual maturity may therefore be attained at about 4–5 years. A few spawning females were collected in the Kermadec region, and at East Cape, suggesting that moonfish spawn in northern New Zealand. Identification of the location and timing of spawning are important areas of further research and are a pre-requisite for obtaining good estimates of length and age at maturity.

Moonfish in New Zealand waters may be a species complex of *L. guttatus* and a new species, large eye moonfish. This needs clarification in New Zealand.

3. STOCKS AND AREAS

There is no information on the stock structure of moonfish.

4. ENVIRONMENTAL AND ECOSYSTEM CONSIDERATIONS

This section was updated for the November 2014 Fishery Assessment Plenary after review by the Aquatic Environment Working Group. This summary is from the perspective of moonfish but there is no directed fishery for them and the incidental catch sections below reflect the New Zealand longline fishery as a whole and are not specific to this species; a more detailed summary from an issue-by-issue perspective is available in the Aquatic Environment and Biodiversity Annual Review where the consequences are also discussed (http://www.mpi.govt.nz/Default.aspx?TabId=126&id=2122) (Ministry for Primary Industries 2013a).

4.1 Role in the ecosystem

Moonfish (*Lampris guttatus*) are a mid-water pelagic fish, found between 50 and 400 m depth. They often exhibit vertical behaviour like many other large pelagic visual predators, including swordfish and bigeye tuna, with deeper day and shallower night depth distributions (Polovina et al 2008). While no published data exists on the diet of *L. guttatus* in the South Pacific, a study on the diet of southern moonfish (*Lampris immaculatus*) along the Patagonian Shelf showed they had a narrow range of prey items with the most common being the deepwater onychoteuthid squid (*Moroteuthis ingens*) (Jackson et al. 2000; Polovina et al 2008). Large pelagic sharks such as great white and mako are thought to prey on moonfish.

4.2 Incidental catch (seabirds, sea turtles and mammals)

The protected species, capture estimates presented here include all animals recovered onto the deck (alive, injured or dead) of fishing vessels but do not include any cryptic mortality (e.g., seabirds caught on a hook but not brought onboard the vessel).

4.2.1 Seabird bycatch

Between 2002–03 and 2012–13, there were 818 observed captures of birds across other surface longline target fisheries (those not targeting albacore tuna, bigeye tuna, southern bluefin tuna, pacific bluefin tuna and swordfish). Seabird capture rates since 2003 are presented in Table 5 and Figures 5 and 6. Seabird captures were more frequent off the south west coast of the South Island (Figure 7). Bayesian models of varying complexity dependent on data quality have been used to estimate captures across a range of methods (Richard & Abraham 2014). Observed and estimated seabird captures in albacore longline fisheries are provided in Table 6.

Through the 1990s the minimum seabird mitigation requirement for surface longline vessels was the use of a bird scaring device (tori line) but common practice was that vessels set surface longlines primarily at night. In 2007 a notice was implemented under s 11 of the Fisheries Act 1996 to formalise the requirement that surface longline vessels only set during the hours of darkness and use a tori line when setting. This notice was amended in 2008 to add the option of line weighting and tori line use if setting during the day. In 2011 the notices were combined and repromulgated under a new regulation (Regulation 58A of the Fisheries (Commercial Fishing) Regulations 2001) which provides a more flexible regulatory environment under which to set seabird mitigation requirements.

Risk posed by commercial fishing to seabirds has been assessed via a level 2 method which supports much of the NPOA-Seabirds 2013 risk assessment framework (MPI 2013b). The method used in the level 2 risk assessment arose initially from an expert workshop hosted by the Ministry of Fisheries in 2008. The overall framework is described in Sharp et al. (2011) and has been variously applied and improved in multiple iterations (Waugh et al. 2009, Richard et al. 2011, Richard and Abraham 2013, Richard et al. 2013 and Richard & Abraham in press). The method applies an “exposure-effects” approach where exposure refers to the number of fatalities is calculated from the overlap of seabirds with fishing effort compared with observed captures to estimate the species vulnerability (capture rates per encounter) to each fishery group. This is then compared to the population's productivity, based on population estimates and biological characteristics to yield estimates of population-level risk.

The 2014 iteration of the seabird risk assessment (Richard & Abraham in press) assessed other surface longline target fisheries (those not targeting albacore tuna, bigeye tuna, southern bluefin tuna, pacific bluefin tuna and swordfish) contribution to the total risk posed by New Zealand commercial fishing to seabirds (see Table 7). These target fisheries contribute 0.003 of PBR_1 to the risk to Southern Buller's albatross which was assessed to be at very high risk from New Zealand commercial fishing (Richard & Abraham in press).

Table 5: Number of observed seabird captures in the New Zealand surface longline fisheries, 2002–03 to 2012–13, by species and area. See glossary above for a description of the areas used for summarising the fishing effort and protected species captures. The risk ratio is an estimate of aggregate potential fatalities across trawl and longline fisheries relative to the Potential Biological Removals, PBR (from Richard and Abraham (2013) where full details of the risk assessment approach can be found). It is not an estimate of the risk posed by fishing for moonfish using longline gear but rather the total risk for each seabird species. Other data, version 20130305.

Albatross Species	Risk Ratio	Kermadec Islands	Northland and Hauraki	Bay of Plenty	East Coast North Island	Stewart Snares Shelf	Fiordland	West Coast South Island	West Coast North Island	Total
Salvin's	Very high	0	1	2	6	0	0	0	0	9
Southern Buller's	Very high	0	5	2	27	0	280	39	0	353
NZ white-capped	Very high	0	2	0	3	10	62	36	1	114
Northern Buller's	High	0	0	0	1	0	0	0	0	1
Gibson's	High	4	16	0	17	0	6	3	1	47
Antipodean	High	12	10	1	8	0	0	0	1	32
Northern royal	Medium	0	0	1	0	0	0	0	0	1
Southern royal	Medium	0	1	0	0	0	4	1	0	6
Campbell black-browed	Medium	2	10	2	29	0	3	3	1	50
Light-mantled sooty	Very low	0	0	0	0	0	0	1	0	1
Unidentified	N/A	38	2	0	2	0	0	0	1	43
Total	**N/A**	**56**	**47**	**8**	**93**	**10**	**355**	**83**	**5**	**657**

Other seabirds

	Risk Ratio	Kermadec Islands	Northland and Hauraki	Bay of Plenty	East Coast North Island	Stewart Snares Shelf	Fiordland	West Coast South Island	West Coast North Island	Total
Black petrel	Very high	1	10	1	0	0	0	0	1	13
Flesh-footed shearwater	Very high	0	0	0	10	0	0	0	2	12
Cape petrel	High	0	0	0	2	0	0	0	0	2
Westland petrel	Medium	0	0	0	2	0	1	6	0	9
White-chinned petrel	Medium	2	3	3	3	1	20	3	3	38
Grey petrel	Medium	3	4	3	38	0	0	0	0	48
Grey-faced petrel	Very low	12	5	1	2	0	0	0	0	20
Sooty shearwater	Very low	1	0	0	8	3	1	0	0	13
Southern giant petrel	-	0	0	2	0	0	0	0	2	0
White-headed petrel	-	2	0	0	0	0	0	0	0	2
Unidentified	N/A	0	1	0	0	0	1	0	0	2
Total	**N/A**	**21**	**23**	**10**	**65**	**4**	**23**	**9**	**8**	**159**

Table 6: Effort, observed and estimated seabird captures by fishing year for the New Zealand surface longline fishery within the EEZ. For each fishing year, the table gives the total number of hooks; the number of observed hooks; observer coverage (the percentage of hooks that were observed); the number of observed captures; the capture rate (captures per thousand hooks); and the mean number of estimated total captures (with 95% confidence interval). Estimates are based on methods described in Thompson et al (2013) and are available via http://www.fish.govt.nz/en-nz/Environmental/Seabirds/. Estimates from 2002–03 to 2010–11 and preliminary estimates for 2012–13 are based on data version 20140131.

		Fishing effort		Observed captures		Estimated captures	
Fishing year	All hooks	Observed hooks	% observed	Number	Rate	Mean	95% c.i.
2002–2003	10 772 188	2 195 152	20.4	115	0.052	2 088	1 613–2 807
2003–2004	7 386 329	1 607 304	21.8	71	0.044	1 395	1 086–1 851
2004–2005	3 679 765	783 812	21.3	41	0.052	617	483–793
2005–2006	3 690 119	705 945	19.1	37	0.052	808	611–1 132
2006–2007	3 739 912	1 040 948	27.8	187	0.18	958	736–1 345
2007–2008	2 246 189	421 900	18.8	37	0.088	524	417–676
2008–2009	3 115 633	937 496	30.1	57	0.061	609	493–766
2009–2010	2 995 264	665 883	22.2	135	0.203	939	749–1 216
2010–2011	3 187 879	674 572	21.2	47	0.07	705	532–964
2011–2012	3 100 277	728 190	23.5	64	0.088	829	617–1 161
2012–2013†	2 862 182	560 333	19.6	27	0.048	783	567–1 144

†Provisional data, model estimates not finalised.

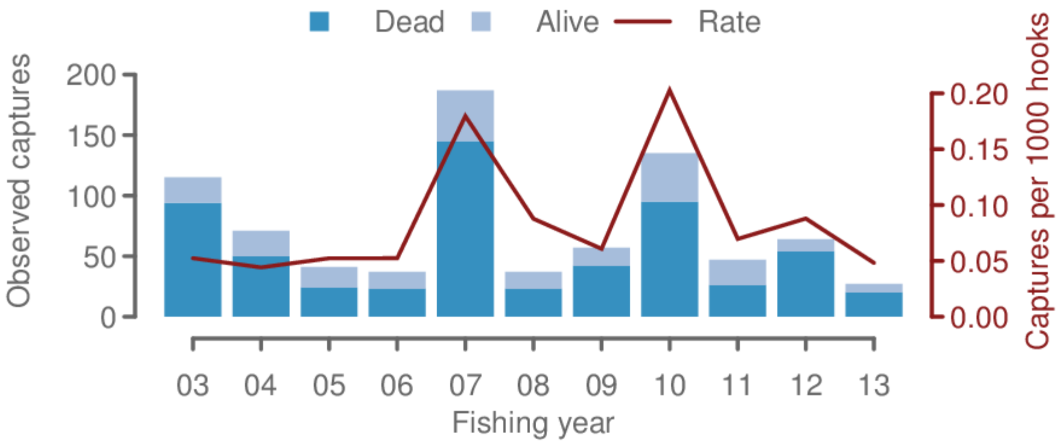


Figure 5: Observed captures of seabirds in the New Zealand surface longline fisheries from 2002–03 to 2012–13.

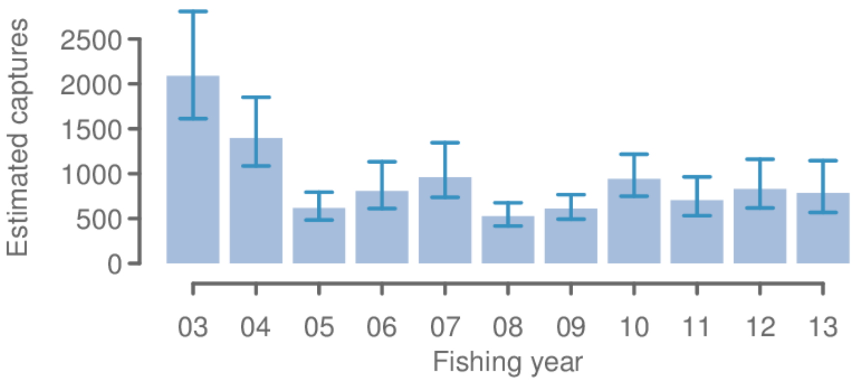


Figure 6: Estimated captures of seabirds in the New Zealand surface longline fisheries from 2002–03 to 2012–13.

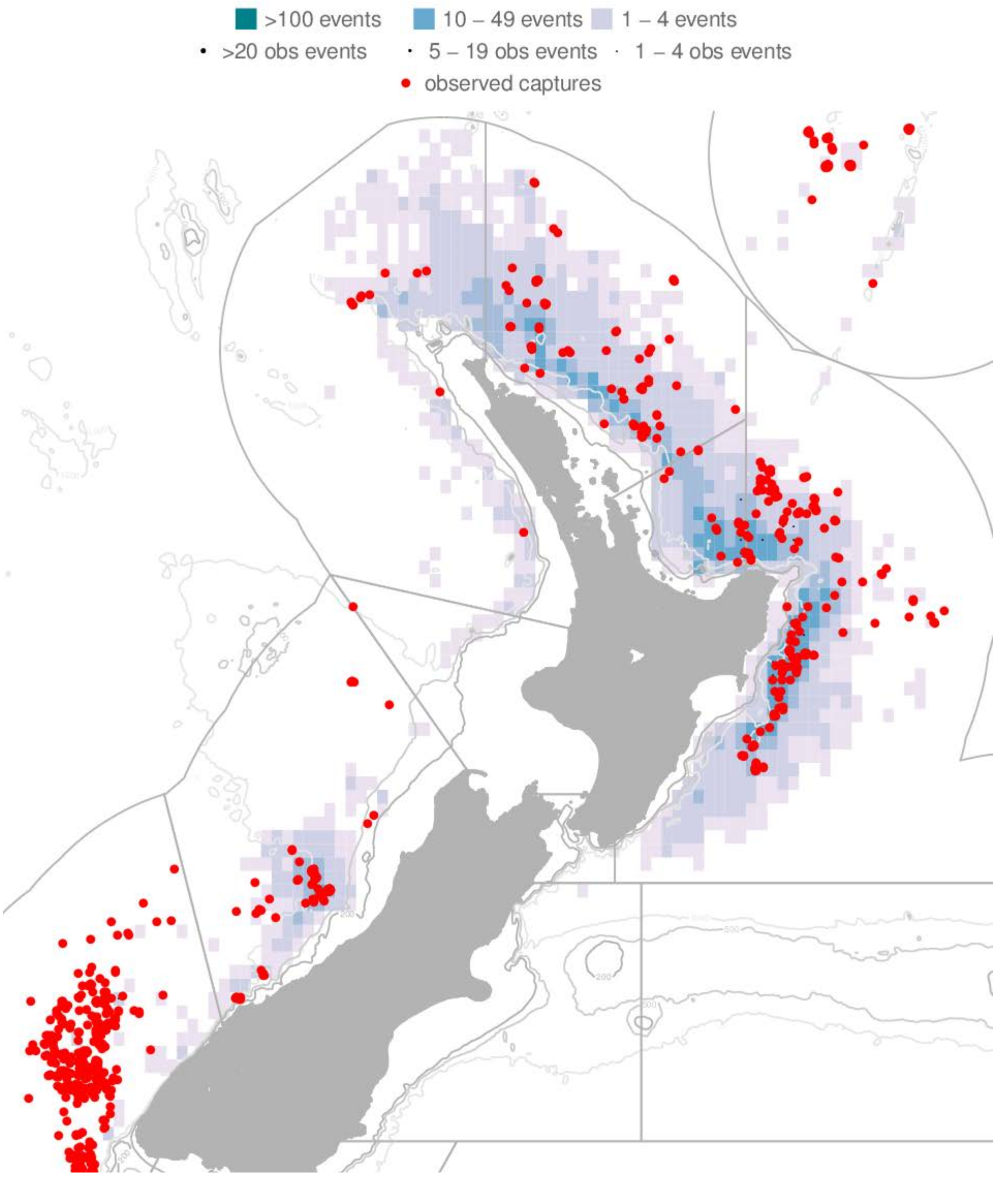


Figure 7: Distribution of fishing effort in the New Zealand surface longline fisheries and observed seabird captures, 2002–03 to 2012–13. Fishing effort is mapped into 0.2-degree cells, with the colour of each cell being related to the amount of effort. Observed fishing events are indicated by black dots, and observed captures are indicated by red dots. Fishing is only shown if the effort could be assigned a latitude and longitude, and if there were three or more vessels fishing within a cell. In this case, 89.4% of the effort is shown. See glossary for areas used for summarising the fishing effort and protected species captures.

Table 7: Risk ratio of seabirds predicted by the level two risk assessment for the other species target surface longline fisheries (those not targeting albacore tuna, bigeye tuna, southern bluefin tuna, pacific bluefin tuna and swordfish) and all fisheries included in the level two risk assessment, 2006–07 to 2012–13, showing seabird species with risk category of very or high, or a medium risk category and risk ratio of at least 1% of the total risk. The risk ratio is an estimate of aggregate potential fatalities across trawl and longline fisheries relative to the Potential Biological Removals, PBR_1 (from Richard and Abraham 2014 where full details of the risk assessment approach can be found). PBR_1 applies a recovery factor of 1.0. Typically a recovery factor of 0.1 to 0.5 is applied (based on the state of the population) to allow for recovery from low population sizes as quickly as possible. This should be considered when interpreting these results. The New Zealand threat classifications are shown (Robertson et al 2013 at http://www.doc.govt.nz/documents/science-and-technical/nztcs4entire.pdf)

	Risk ratio				
Species name	OTH target SLL	Total risk from NZ commercial fishing	% of total risk from NZ commercial fishing	Risk category	NZ Threat Classification
Black petrel	0.000	15.095	0.00	Very high	Threatened: Nationally Vulnerable
Salvin's albatross	0.000	3.543	0.00	Very high	Threatened: Nationally Critical
Southern Buller's albatross	0.003	2.823	0.10	Very high	At Risk: Naturally Uncommon
Flesh-footed shearwater	0.000	1.557	0.00	Very high	Threatened: Nationally Vulnerable
Gibson's albatross	0.000	1.245	0.00	Very high	Threatened: Nationally Critical
New Zealand white-capped albatross	0.000	1.096	0.01	Very high	At Risk: Declining
Chatham Island albatross	0.000	0.913	0.00	High	At Risk: Naturally Uncommon
Antipodean albatross	0.000	0.888	0.00	High	Threatened: Nationally Critical
Westland petrel	0.000	0.498	0.00	High	At Risk: Naturally Uncommon
Northern Buller's albatross	0.000	0.336	0.13	High	At Risk: Naturally Uncommon
Campbell black-browed albatross	0.000	0.304	0.00	High	At Risk: Naturally Uncommon
Stewart Island shag	0.000	0.301	0.00	High	Threatened: Nationally Vulnerable

4.2.2 Sea turtle bycatch

Between 2002–03 and 2012–13, there were 15 observed captures of sea turtles across all surface longline fisheries (Tables 8 and 9, Figure 8). Observer records documented all but one sea turtle as captured and released alive. Sea turtle capture distributions predominantly occur throughout the east coast of the North Island and Kermadec Island fisheries (Figure 9).

Table 8: Number of observed sea turtle captures in the New Zealand surface longline fisheries, 2002–03 to 2012–13, by species and area. Data from Thompson et al (2013), retrieved from http://data.dragonfly.co.nz/psc/. See glossary above for a description of the areas used for summarising the fishing effort and protected species captures.

Species	Bay of Plenty	East Coast North Island	Kermadec Islands	West Coast North Island	Total
Leatherback turtle	1	4	3	3	11
Green turtle	0	1	0	0	1
Unknown turtle	0	1	0	2	3
Total	1	6	3	5	15

Table 9: Effort and sea turtle captures in surface longline fisheries by fishing year. For each fishing year, the table gives the total number of hooks; the number of observed hooks; observer coverage (the percentage of hooks that were observed); the number of observed captures (both dead and alive); and the capture rate (captures per thousand hooks). For more information on the methods used to prepare the data see Thompson et al (2013).

	Fishing effort			Observed captures	
Fishing year	All hooks	Observed hooks	% observed	Number	Rate
2002–2003	10 772 188	2 195 152	20.4	0	0
2003–2004	7 386 329	1 607 304	21.8	1	0.001
2004–2005	3 679 765	783 812	21.3	2	0.003
2005–2006	3 690 119	705 945	19.1	1	0.001
2006–2007	3 739 912	1 040 948	27.8	2	0.002
2007–2008	2 246 189	421 900	18.8	1	0.002
2008–2009	3 115 633	937 496	30.1	2	0.002
2009–2010	2 995 264	665 883	22.2	0	0
2010–2011	3 187 879	674 572	21.2	4	0.006
2011–2012	3 100 277	728 190	23.5	0	0
2012–2013	2 862 182	560 333	19.6	2	0.004

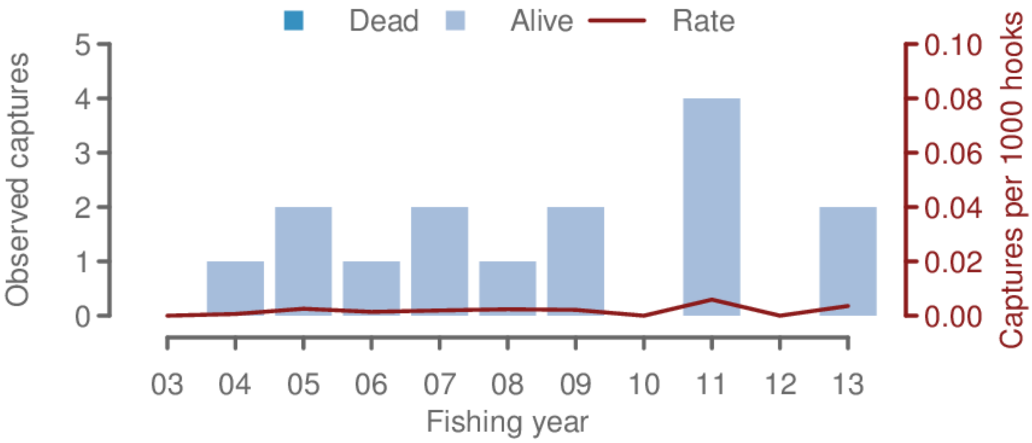


Figure 8: Observed captures of sea turtles in the New Zealand surface longline fisheries from 2002–03 to 2012–13.

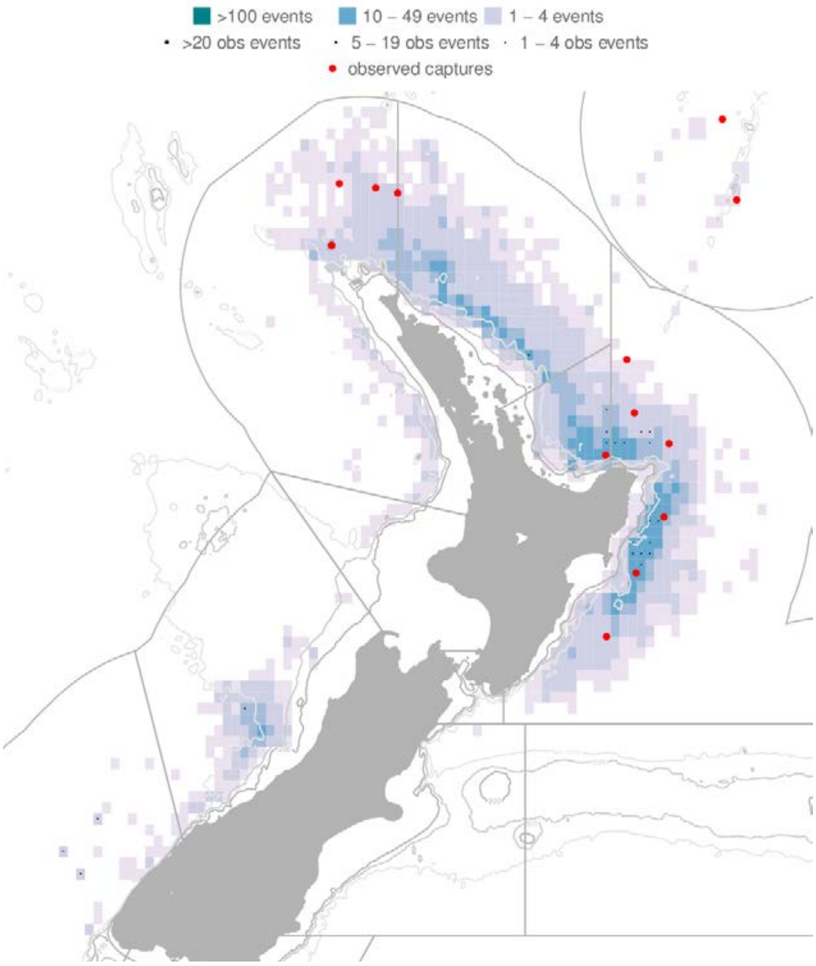


Figure 9: Distribution of fishing effort in the New Zealand surface longline fisheries and observed sea turtle captures, 2002–03 to 2012–13. Fishing effort is mapped into 0.2-degree cells, with the colour of each cell being related to the amount of effort. Observed fishing events are indicated by black dots, and observed captures are indicated by red dots. Fishing is only shown if the effort could be assigned a latitude and longitude, and if there were three or more vessels fishing within a cell. In this case, 89.4% of the effort is shown. See glossary for areas used for summarising the fishing effort and protected species captures.

4.2.3 Marine Mammals

4.2.3.1 Cetaceans

Cetaceans are dispersed throughout New Zealand waters (Perrin et al 2008). The spatial and temporal overlap of commercial fishing grounds and cetacean foraging areas has resulted in cetacean captures in fishing gear (Abraham & Thompson 2009, 2011).

Between 2002–03 and 2012–13, there were seven observed captures of whales and dolphins in surface longline fisheries. Observed captures included 5 unidentified cetaceans and 2 long-finned Pilot whales (Tables 10 and 11, Figure 10) (Thompson et al 2013). All captured animals recorded were documented as being caught and released alive (Thompson et al 2013). Cetacean capture distributions are more frequent off the east coast of the North Island (Figure 11).

Table 10: Number of observed cetacean captures in the New Zealand surface longline fisheries, 2002–03 to 2012–13, by species and area. Data from Thompson et al (2013), retrieved from http://data.dragonfly.co.nz/psc/. See glossary above for a description of the areas used for summarising the fishing effort and protected species captures.

Species	Bay of Plenty	East Coast North Island	Fiordland	Northland and Hauraki	West Coast North Island	West Coast South Island	Total
Long-finned pilot whale	0	1	0	0	0	1	2
Unidentified cetacean	1	1	1	1	1	0	5
Total	1	2	1	1	1	1	7

Table 11: Effort and captures of cetaceans in surface longline fisheries by fishing year. For each fishing year, the table gives the total number of hooks; the number of observed hooks; observer coverage (the percentage of hooks that were observed); the number of observed captures (both dead and alive); and the capture rate (captures per thousand hooks). For more information on the methods used to prepare the data, see Thompson et al (2013).

			Fishing effort	Observed captures	
Fishing year	All hooks	Observed hooks	% observed	Number	Rate
2002–2003	10 772 188	2 195 152	20.4	1	0
2003–2004	7 386 329	1 607 304	21.8	4	0.002
2004–2005	3 679 765	783 812	21.3	1	0.001
2005–2006	3 690 119	705 945	19.1	0	0
2006–2007	3 739 912	1 040 948	27.8	0	0
2007–2008	2 246 189	421 900	18.8	1	0.002
2008–2009	3 115 633	937 496	30.1	0	0
2009–2010	2 995 264	665 883	22.2	0	0
2010–2011	3 187 879	674 572	21.2	0	0
2011–2012	3 100 277	728 190	23.5	0	0
2012–2013	2 862 182	560 333	19.6	0	0

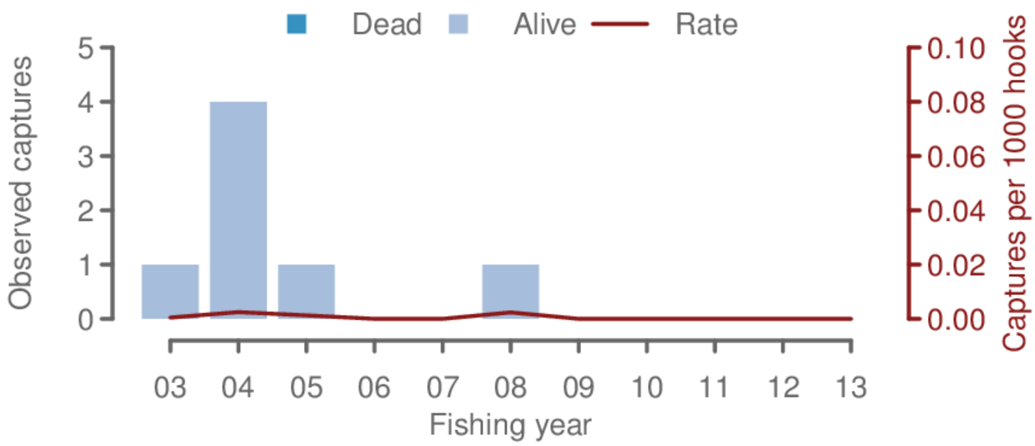


Figure 10: Observed captures of cetaceans in the New Zealand surface longline fisheries from 2002–03 to 2012–13.

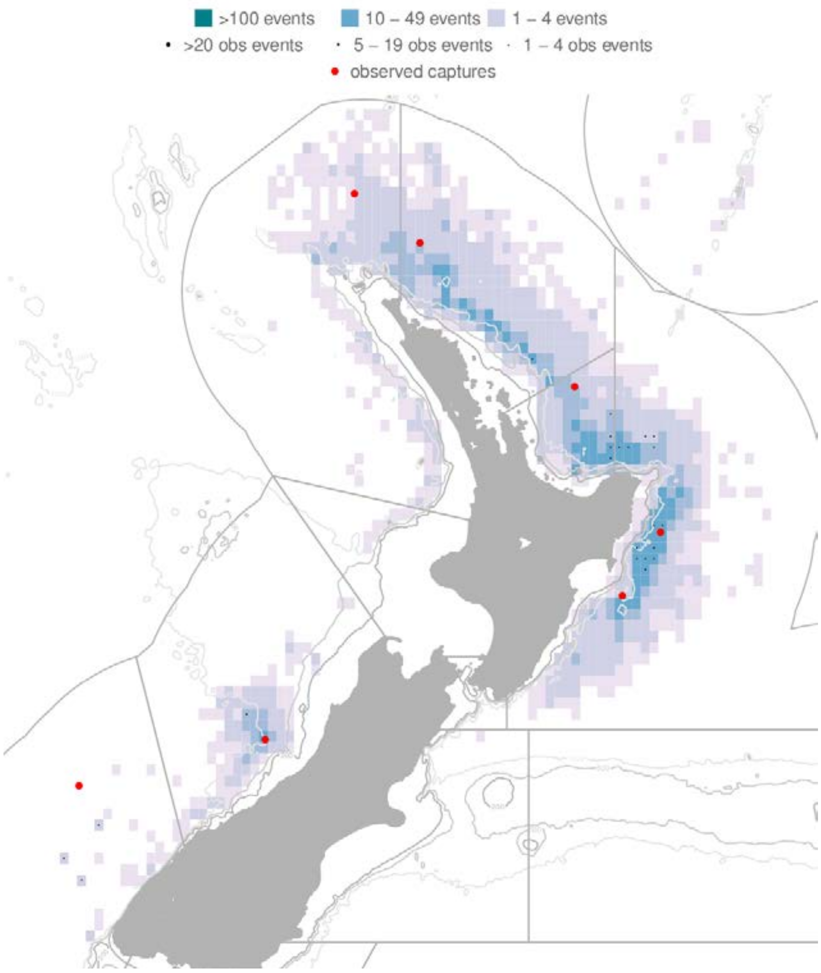


Figure 11: Distribution of fishing effort in the New Zealand surface longline fisheries and observed cetacean captures, 2002–03 to 2012–13. Fishing effort is mapped into 0.2-degree cells, with the colour of each cell being related to the amount of effort. Observed fishing events are indicated by black dots, and observed captures are indicated by red dots. Fishing is only shown if the effort could be assigned a latitude and longitude, and if there were three or more vessels fishing within a cell. In this case, 89.4% of the effort is shown. See glossary for areas used for summarising the fishing effort and protected species captures.

4.2.3.2 New Zealand fur seal bycatch

Currently, New Zealand fur seals are dispersed throughout New Zealand waters, especially in waters south of about 40º S to Macquarie Island. The spatial and temporal overlap of commercial fishing grounds and New Zealand fur seal foraging areas has resulted in New Zealand fur seal captures in fishing gear (Mattlin 1987, Rowe 2009). Most fisheries with observed captures occur in waters over or close to the continental shelf, which slopes steeply to deeper waters relatively close to shore, and thus rookeries and haulouts, around much of the South Island and offshore islands. Captures on longlines occur when the fur seals attempt to feed on the bait and fish catch during hauling. Most New Zealand fur seals are released alive, typically with a hook and short snood or trace still attached.

New Zealand fur seal captures in surface longline fisheries have been generally observed in waters south and west of Fiordland, but also in the Bay of Plenty-East Cape area when the animals have attempted to take bait or fish from the line as it is hauled. These capture rates include animals that are released alive (100% of observed surface longline capture in 2008–09; Thompson & Abraham 2010). Capture rates in 2011–12 and 2012-13 were higher than they were in the early 2000s (Figures 12 and 13). While fur seal captures have occurred throughout the

range of this fishery most New Zealand captures have occurred off the Southwest coast of the South Island (Figure 14). Between 2002–03 and 2012–13, there were 267 observed captures of New Zealand fur seal in surface longline fisheries (Tables 12 and 13).

Table 12: Number of observed New Zealand fur seal captures in the New Zealand surface longline fisheries, 2002–03 to 2012–13, by species and area. Data from Thompson et al (2013), retrieved from http://data.dragonfly.co.nz/psc/. See glossary above for a description of the areas used for summarising the fishing effort and protected species captures.

	Bay of Plenty	East Coast North Island	Fiordland	Northland and Hauraki	Stewart Snares Shelf	West Coast North Island	West Coast South Island	Total
New Zealand fur seal	11	33	179	4	4	2	34	267

Table 13: Effort and captures of New Zealand fur seal in the New Zealand surface longline fisheries by fishing year. For each fishing year, the table gives the total number of hooks; the number of observed hooks; observer coverage (the percentage of hooks that were observed); the number of observed captures (both dead and alive); and the capture rate (captures per thousand hooks). Data from Thompson et al (2013), retrieved from http://data.dragonfly.co.nz/psc/. Estimates from 2002–03 to 2010–11 and preliminary estimates for 2012–13 are based on data version 20140131.

	Fishing effort			Observed captures		Estimated captures	
Fishing year	All hooks	Observed hooks	% observed	Number	Rate	Mean	95% c.i.
2002–2003	10 772 188	2 195 152	20.4	56	0.026	299	199–428
2003–2004	7 386 329	1 607 304	21.8	40	0.025	134	90–188
2004–2005	3 679 765	783 812	21.3	20	0.026	66	38–99
2005–2006	3 690 119	705 945	19.1	12	0.017	47	23–79
2006–2007	3 739 912	1 040 948	27.8	10	0.010	32	14–55
2007–2008	2 246 189	421 900	18.8	10	0.024	40	19–68
2008–2009	3 115 633	937 496	30.1	22	0.023	53	29–81
2009–2010	2 995 264	665 883	22.2	19	0.029	77	43–121
2010–2011	3 187 879	674 572	21.2	17	0.025	64	35–101
2011–2012	3 100 277	728 190	23.5	40	0.055	140	92–198
2012–2013†	2 862 182	560 333	19.6	21	0.037	110	65–171

†Provisional data, model estimates not finalised.

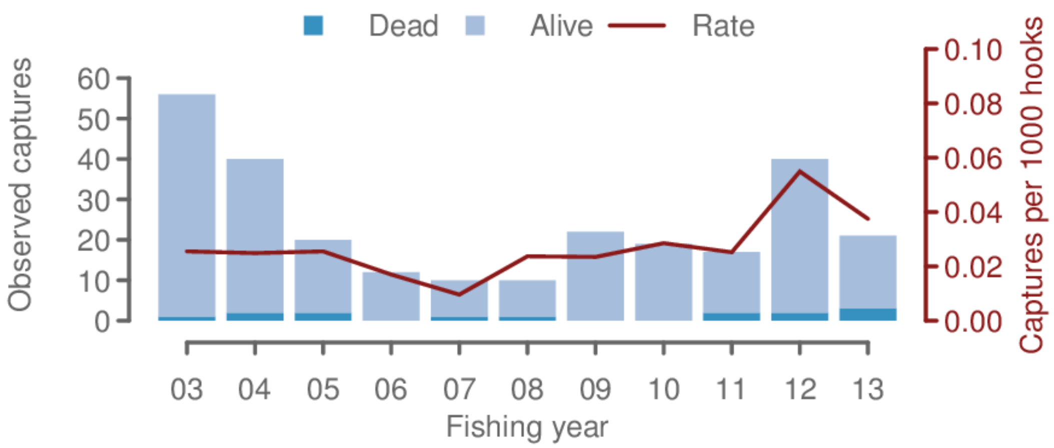


Figure 12: Observed captures of New Zealand fur seal in the New Zealand surface longline fisheries from 2002–03 to 2012–13.

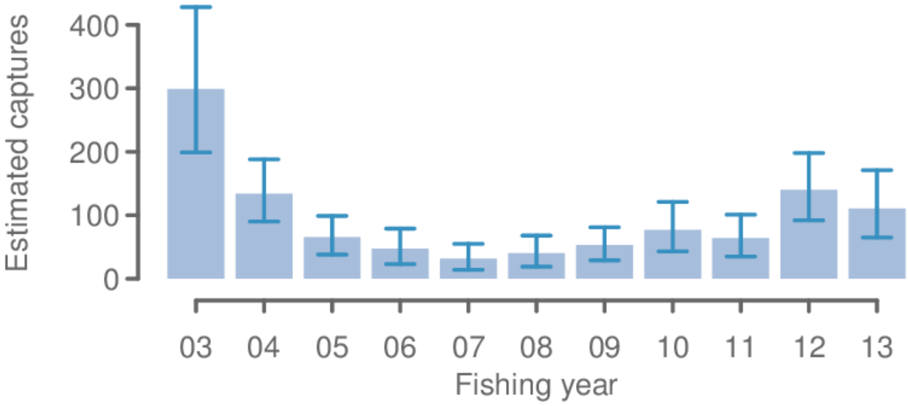


Figure 13: Estimated captures of New Zealand fur seal in the New Zealand surface longline fisheries from 2002–03 to 2012–13.

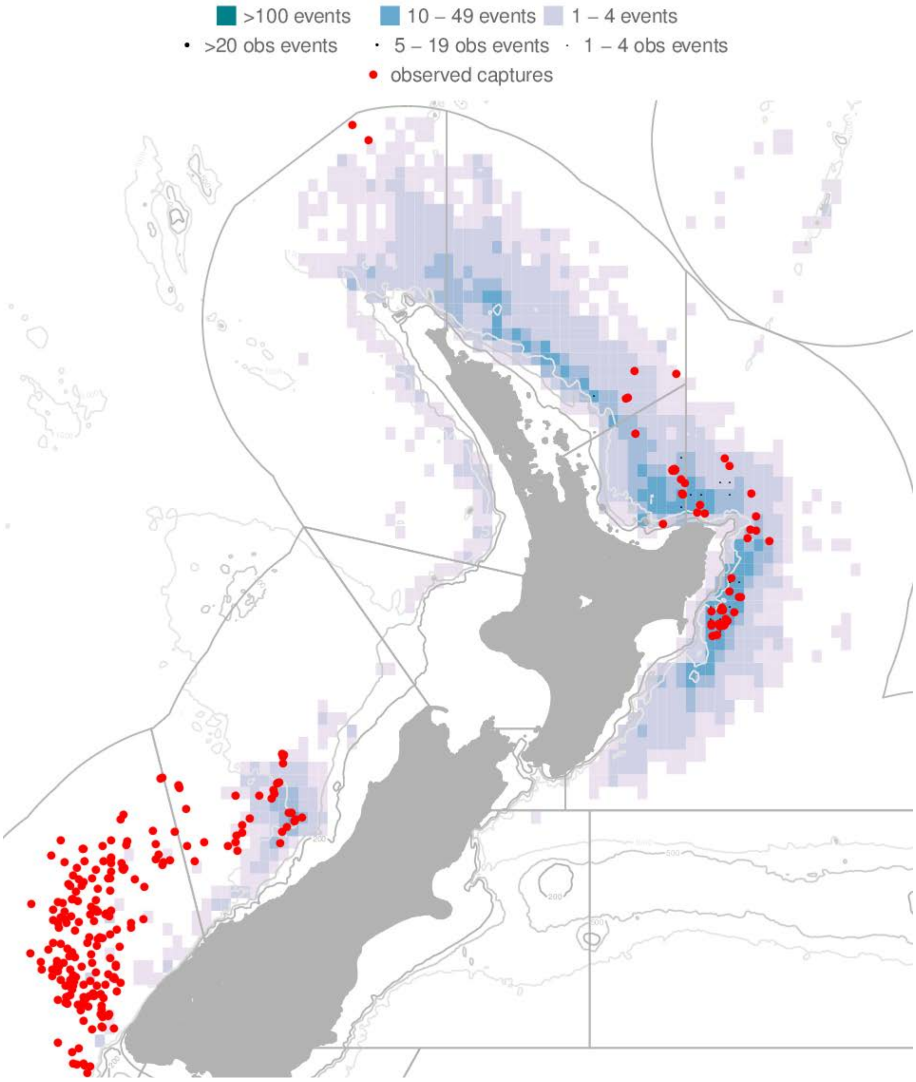


Figure 14: Distribution of fishing effort in the New Zealand surface longline fisheries and observed New Zealand fur seal captures, 2002–03 to 2012–13. Fishing effort is mapped into 0.2-degree cells, with the colour of each cell being related to the amount of effort. Observed fishing events are indicated by black dots, and observed captures are indicated by red dots. Fishing is only shown if the effort could be assigned a latitude and longitude, and if there were three or more vessels fishing within a cell. In this case, 89.4% of the effort is shown. See glossary for areas used for summarising the fishing effort and protected species captures.

4.3 Incidental fish bycatch

Observer records indicate that a wide range of species are landed by the longline fleets in New Zealand fishery waters. Blue sharks are the most commonly landed species (by number), followed by Ray's bream (Table 14). Southern bluefin tuna and albacore tuna are the only target species that occur in the top five of the frequency of occurrence.

Table 14: Total estimated catch (numbers of fish) of common bycatch species in the New Zealand longline fishery as estimated from observer data from 2009 to 2013. Also provided is the percentage of these species retained (2013 data only) and the percentage of fish that were alive when discarded, N/A (none discarded).

Species	2010	2011	2012	2013	% retained (2013)	discards % alive (2013)
Blue shark	66113	53432	132925	158736	45.2	97.4
Lancetfish	43425	37305	7866	19172	0.1	37.6
Rays bream	20041	18453	19918	13568	97.4	4.2
Porbeagle shark	4679	9929	7019	9805	34.0	79.8
Mako shark	4490	9770	3902	3981	35.5	84.9
Moonfish	5398	3418	2363	2470	99.0	0.0
Escolar	1539	6602	2181	2088	30.2	76.3
Sunfish	3148	3773	3265	1937	2.7	100.0
Pelagic stingray	1983	4090	712	1199	1.0	97.0
Butterfly tuna	1158	909	713	1030	48.1	11.1
Deepwater dogfish	377	548	647	743	1.2	88.5
Oilfish	886	1747	509	386	26.5	72.2
Rudderfish	326	338	491	362	13.0	80.0
Thresher shark	209	349	246	256	33.3	75.0
Skipjack tuna	91	255	123	240	100.0	N/A
Dealfish	1160	223	372	237	1.7	25.1
Striped marlin	471	175	124	182	0.0	44.4
Big scale pomfret	505	139	108	67	88.2	100.0
School shark	62	49	477	21	100.0	N/A

4.4 Benthic interactions

N/A

4.5 Key environmental and ecosystem information gaps

Cryptic mortality is unknown at present but developing a better understanding of this in future may be useful for reducing uncertainty of the seabird risk assessment and could be a useful input into risk assessments for other species groups.

The survival rates of released target and bycatch species is currently unknown.

Observer coverage in the New Zealand fleet is not spatially and temporally representative of the fishing effort.

5. STOCK ASSESSMENT

There is insufficient information to conduct a stock assessment of moonfish.

CPUE estimates were calculated for each fleet and area stratum in which eight or more sets were observed and at least 2% of the hooks were observed. CPUE estimates were calculated for moonfish for each fleet and area in 2006–07 to 2009–10 and added to the time series for 1988–89 to 2005–06 (Griggs et al 2008) and these are shown in Figure 13 (Griggs & Baird 2013). The

CPUE results from the Domestic fleet should be interpreted with caution due to the lower observer coverage of this fleet. CPUE estimates for the Charter fleet can be considered reliable from 1992–93 onwards (Griggs et al 2007). The CPUE trends show high catch rates in the 1990s and there is some indication that these are increasing again in the late 2000s (Figure 15).

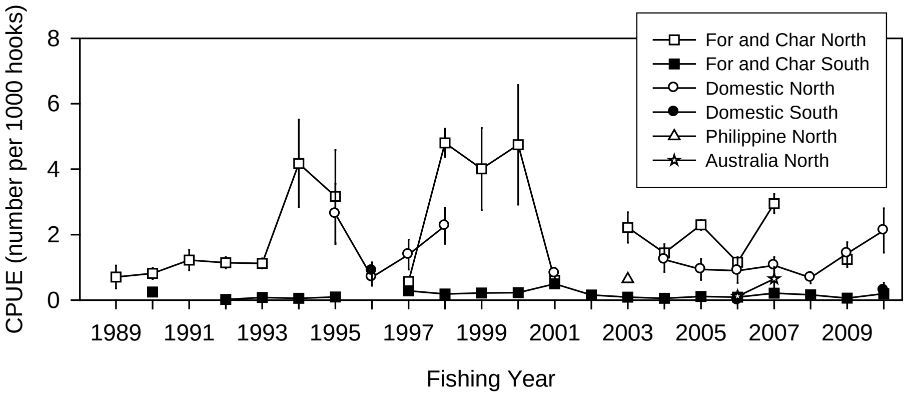


Figure 15: Annual variation in moonfish CPUE by fleet and area. Plotted values are the mean estimates with 95% confidence limits. Fishing year 1989 = October 1988 to September 1989 (Griggs & Baird 2013).

5.1 Estimates of fishery parameters and abundance

There are no estimates of relevant fisheries parameters or abundance indices for moonfish.

5.2 Biomass estimates

There are no biomass estimates for moonfish.

5.3 Other yield estimates and stock assessment results

There are no other yield estimates or stock assessment results.

5.4 Other factors

While there is little information on stock status, available data suggests that moonfish are moderately productive and that most (71%) of New Zealand's catches are of mature fish. Provided that juvenile moonfish are not experiencing high fishing mortality elsewhere in their range, it is unlikely that the stock is currently depleted.

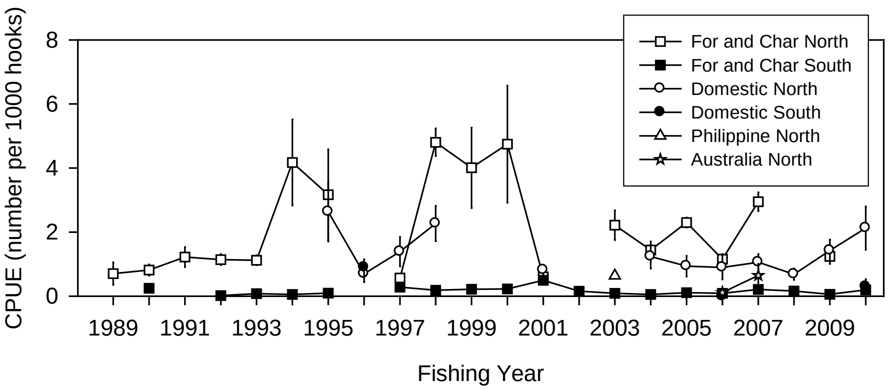
6. STATUS OF THE STOCKS

Stock structure assumptions

MOO 1 is assumed to be part of the wider South Western Pacific Ocean stock but the text below relates only to the New Zealand component of that stock.

Stock Status	
Year of Most Recent Assessment	No assessment
Assessment Runs Presented	-
Reference Points	Target: Not established Soft Limit: Not established by WCPFC; but HSS default of 20% SB_0 assumed Hard Limit: Not established by WCPFC; but HSS default of 10% SB_0 assumed Overfishing threshold: Unknown
Status in relation to Target	Unknown
Status in relation to Limits	Unknown
Status in relation to Overfishing	Unknown

Historical Stock Status Trajectory and Current Status



Annual variation in moonfish CPUE by fleet and area. Plotted values are the mean estimates with 95% confidence limits. Fishing year 1989 = October 1988 to September 1989 (Griggs & Baird 2013).

Fishery and Stock Trends	
Recent trend in Biomass or Proxy	Unknown
Recent trend in Fishing Intensity or Proxy	Unknown
Other Abundance Indices	Unknown
Trends in Other Relevant Indicators or Variables	Catches in New Zealand increased from the late 1980s to 2000 but have declined from 351 t in 2000–01 to 43 t in 2007–08, this decline in catch coincides with a decline in longline fishing effort.
Projections and Prognosis	
Stock Projections or Prognosis	Unknown
Probability of Current Catch or TACC causing Biomass to remain below or to decline below Limits	Soft Limit: Unknown Hard Limit: Unknown
Probability of Current Catch or TACC causing Overfishing to continue or to commence	Unknown

Assessment Methodology and Evaluation		
Assessment Type	Level 4: Low information evaluation - There are only data on catch and TACC, with no other fishery indicators	
Assessment Method	2 – Medium or Mixed Quality: information has been subjected to peer review and has been found to have some shortcomings	
Assessment Dates	Latest assessment: 2012	Next assessment:
Overall assessment quality rank	N/A	
Main data inputs (rank)	- Commercial reported catch and effort	1 - High quality for the charter fleet but low for all the other fleets
Data not used (rank)	N/A	
Changes to Model Structure and Assumptions	-	
Major Sources of Uncertainty	-	

Qualifying Comments

This fishery is largely a bycatch fishery. There are some issues associated with species identification with a new species recently described as the large-eye moonfish.

Fishery Interactions
-

7. FOR FURTHER INFORMATION

Abraham, E R; Thompson, F N (2009) Capture of protected species in New Zealand trawl and longline fisheries, 1998–99 to 2006–07. *New Zealand Aquatic Environment and Biodiversity Report No. 32*.

Abraham, E R; Thompson, F N (2011) Summary of the capture of seabirds, marine mammals, and turtles in New Zealand commercial fisheries, 1998–99 to 2008–09. Final Research Report prepared for Ministry of Fisheries project PRO2007/01. (Unpublished report held by the Ministry for Primary Industries, Wellington.) 170 p.

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Anon. (2003) Information summaries and indicative areas for species proposed to be introduced to the QMS in October 2004. NIWA Report on MFish Project MOF2002/03F. (Unpublished report held by Ministry for Primary Industries, Wellington.)

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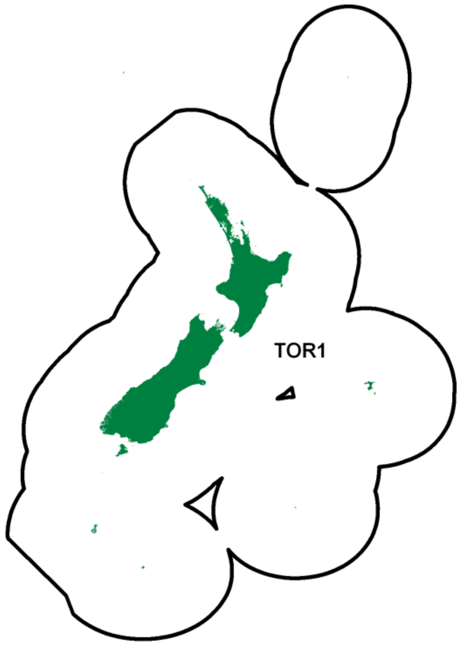
PACIFIC BLUEFIN TUNA (TOR)

(Thunnus orientalis)



1. FISHERY SUMMARY

Pacific bluefin tuna was introduced into the QMS on 1 October 2004 under a single QMA, TOR 1, with allowances, TACC, and TAC in Table 1.

Table 1: Recreational and Customary non-commercial allowances, TACCs and TACs (all in tonnes) for Pacific bluefin tuna.

Fishstock	Recreational Allowance	Customary non-commercial Allowance	Other mortality	TACC	TAC
TOR 1	25	0.50	3.5	116	145

Pacific bluefin tuna were added to the Third Schedule of the 1996 Fisheries Act with a TAC set under s14 because Pacific bluefin tuna is a highly migratory species and it is not possible to estimate MSY for the part of the stock that is found within New Zealand fisheries waters.

Pacific bluefin tuna is believed to be a single Pacific-wide stock and is covered by two regional fisheries management organisations, the Western and Central Pacific Fisheries Commission (WCPFC), and the Inter-American Tropical Tuna Commission (IATTC). They will cooperate in the management of the Pacific bluefin tuna stock throughout the Pacific Ocean. Under the WCPFC Convention, New Zealand is responsible for ensuring that the management measures applied within New Zealand fisheries waters are compatible with those of the Commissions.

1.1 Commercial fisheries

Pacific bluefin tuna was not widely recognised as a distinct species until the late 1990s. It was previously regarded as a sub-species of *Thunnus thynnus* (northern bluefin tuna, NTU). Prior to June 2001, catches of this species were either recorded as NTU or misidentified as southern bluefin tuna. Fishers have since become increasingly able to accurately identify TOR and, from June 2001, catch reports have rapidly increased. Catches of TOR may still be under reported to some degree as there is still some reporting against the NTU code. Recent genetic work suggests that true NTU (*Thunnus thynnus*) are not taken in the New Zealand fishery (see Biology section below for further details). Figure 1 shows the historical landings and domestic longline fishing effort for TOR 1.

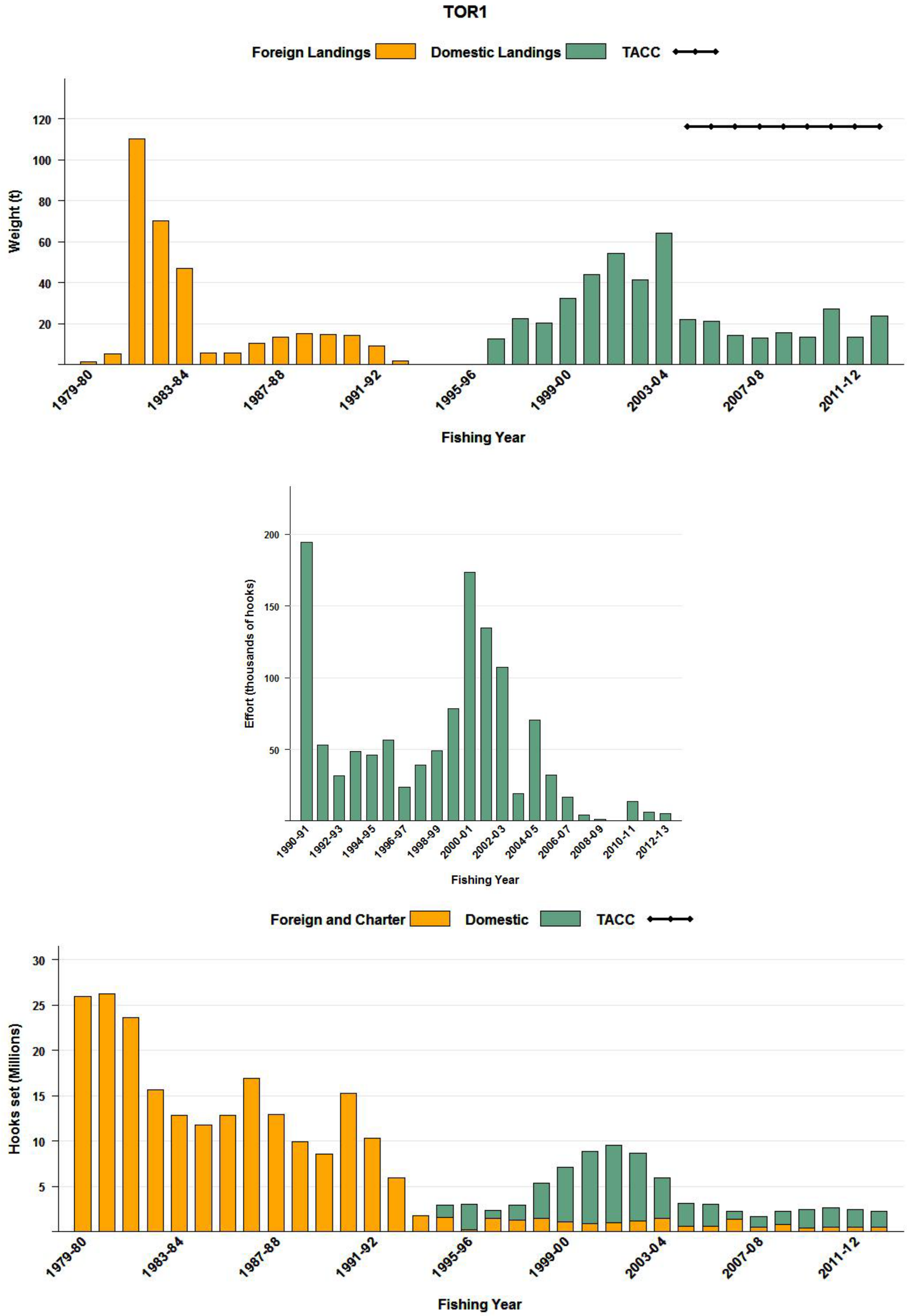


Figure 1: [Top] Commercial catch of pacific bluefin tuna by foreign licensed and New Zealand vessels from 1979–80 to 2012–13 within New Zealand waters (TOR 1). [Middle] Fishing effort (number of hooks set) for high seas New Zealand flagged surface longline vessels, from 1990–91 to 2012–13, and [Bottom] fishing effort (number of hooks set) for all domestic and foreign vessels (including effort by foreign vessels chartered by NZ fishing companies) from 1979–80 to 2012–13.

Table 2: Reported total New Zealand landings (t) of Pacific bluefin tuna (includes landings attributed to NTU), 1991 – present and total Pacific Ocean catches.

Year	NZ landings (t)	Total stock (t)	Year	NZ landings (t)	Total stock (t)	Year	NZ landings (t)	Total stock (t)
1991	1.5	15 781	1999	21.2	29 153	2007	14	21 189
1992	0.3	13 995	2000	20.9	33 900	2008	14.0	24 794
1993	5.6	10 811	2001	49.8	18 712	2009	16.0	19 928
1994	1.9	16 961	2002	55.4	18 959	2010	13.6	18 057
1995	1.8	29 225	2003	40.8	18 419	2011	27.4	17 651
1996	4.2	23 519	2004	67.3	25 357	2012	13.3	15 636
1997	14.3	24 632	2005	20.1	28 988	2013	23.9	12 124
1998	20.4	15 763	2006	21.1	26 074			

Source: NZ landings, for 1991–2002 MPI Licensed Fish Receiver Returns data and Solander Fisheries Ltd. 2003–present MPI MHR data. Total Pacific landings for ISC members from http://isc.ac.affrc.go.jp/index.html. This covers most catches from this stock, but does not include South Pacific catches by coastal states in the South Pacific.

Pacific bluefin has been fished in the New Zealand EEZ since at least 1960, with some catch likely but undocumented prior to that time. New Zealand catches, while increasing, are small compared to total stock removals (Table 2).

Table 3: Reported catches or landings (t) of Pacific bluefin tuna by fleet and Fishing Year. NZ: New Zealand domestic and charter fleet, MHR data from 2001–02 to present ET: catches from New Zealand flagged longline vessels outside these areas, JPNFL: Japanese foreign licensed vessels, KORFL: foreign licensed vessels from the Republic of Korea, and LFRR: Estimated landings from Licensed Fish Receiver Returns.

	TOR 1 (all FMAs)				
Fishing Year	JPNFL	NZ/MHR	Total	LFRR	NZ ET
1979–80	1.5		1.5		
1980–81	5.3		5.3		
1981–82	110.1		110.1		
1982–83	70.1		70.1		
1983–84	47		47		
1984–85	6		6		
1985–86	5.7		5.7		
1986–87	10.6		10.6	0.0	
1987–88	13.5		13.5	0.0	
1988–89	15.1		15.1	0.0	
1989–90	14.7		14.7	0.0	
1990–91	14.5		14.5	1.5	
1991–92	9.1		9.1	0.3	
1992–93	2.1		2.1	5.6	
1993–94	0.1		0.1	1.9	
1994–95			0	1.8	
1995–96			0	4.0	
1996–97		12.5	12.5	13.0	
1997–98		22.5	22.5	20.9	0.4
1998–99		20.6	20.6	17.9	0.1
1999–00		32.6	32.6	23.1	0.1
2000–01		43.9	43.9	51.8	1.0
2001–02		54.4	54.4	53.3	0.0
2002–03		41.6	41.6	39.8	0.0
2003–04		64.3	64.3	58.1	0.0
2004–05		22.9	22.9	22.9	0.0
2005–06		21.1	21.1	20.3	0.0
2006–07		14.3	14.3	14.5	0.0
2007–08		13.1	13.1	11.9	0.0
2008–09		15.7	15.7	15.5	0.0
2009–10		13.6	13.6	12.4	0.0
2010–11		27.4	27.4	26.7	0.0
2011–12		13.7	13.7	13.4	0.0
2012–13		23.9	23.9	23.9	0.0

Catches from within New Zealand fisheries waters are very small compared to those from the greater stock in the Pacific Ocean (0.14% average of the Pacific wide catch for 1999–2009). In contrast to New Zealand, where Pacific bluefin tuna are taken almost exclusively by longline, the majority of catches are taken in purse seine fisheries in the Western and Central Pacific Ocean

(WCPO) (Japan and Korea) and Eastern Pacific Ocean EPO (Mexico). Much of the fish taken by the Mexican fleet are grown in sea pens.

Prior to the introduction to the QMS, the highest catches were made in FMA 1 and FMA 2. While it is possible to catch Pacific bluefin as far south as 48ºS, few catches are made in the colder southern FMAs. Although recent catches have occurred in FMA 7 fish have been in poor condition with little commercial value. Catches are almost exclusively by tuna longlines, typically as a bycatch of sets targeting bigeye tuna. Catches by fishing year and fleet are provided in Table 3.

The majority of Pacific bluefin tuna are caught in the bigeye tuna surface longline fishery (59%), with about 18% of the catch coming from the southern bluefin tuna surface longline fishery (Figure 2). There is no targeted commercial fishery for Pacific bluefin tuna in New Zealand. In New Zealand longline fisheries, Pacific bluefin tuna make up less than 1% of the commercial catch (Figure 3). Longline fishing effort is distributed along the east coast of the North Island and the south west coast of the South Island. The west coast South Island fishery predominantly targets southern bluefin tuna, whereas the east coast of the North Island targets a range of species including bigeye, swordfish, and southern bluefin tuna (Figure 4).

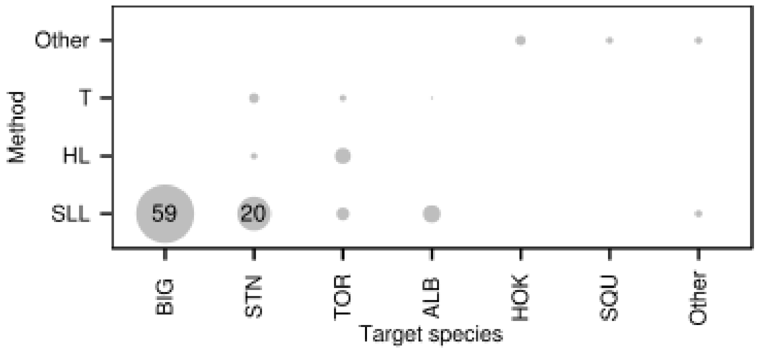


Figure 2: A summary of the proportion of landings of pacific bluefin tuna taken by each target fishery and fishing method. The area of each circle is proportional to the percentage of landings taken using each combination of fishing method and target species. The number in the bobble is the percentage. SLL = surface longline HL = hand line and T = trawl (Bentley et al 2013).

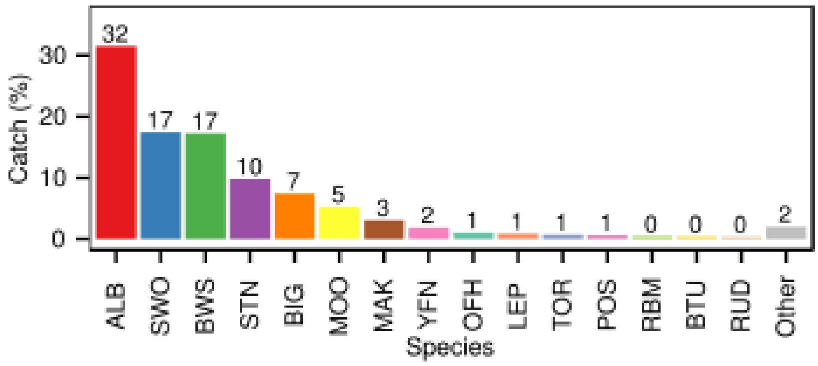


Figure 3: A summary of species composition of the reported surface longline catch. The percentage by weight of each species is calculated for all surface longline trips (Bentley et al 2013).

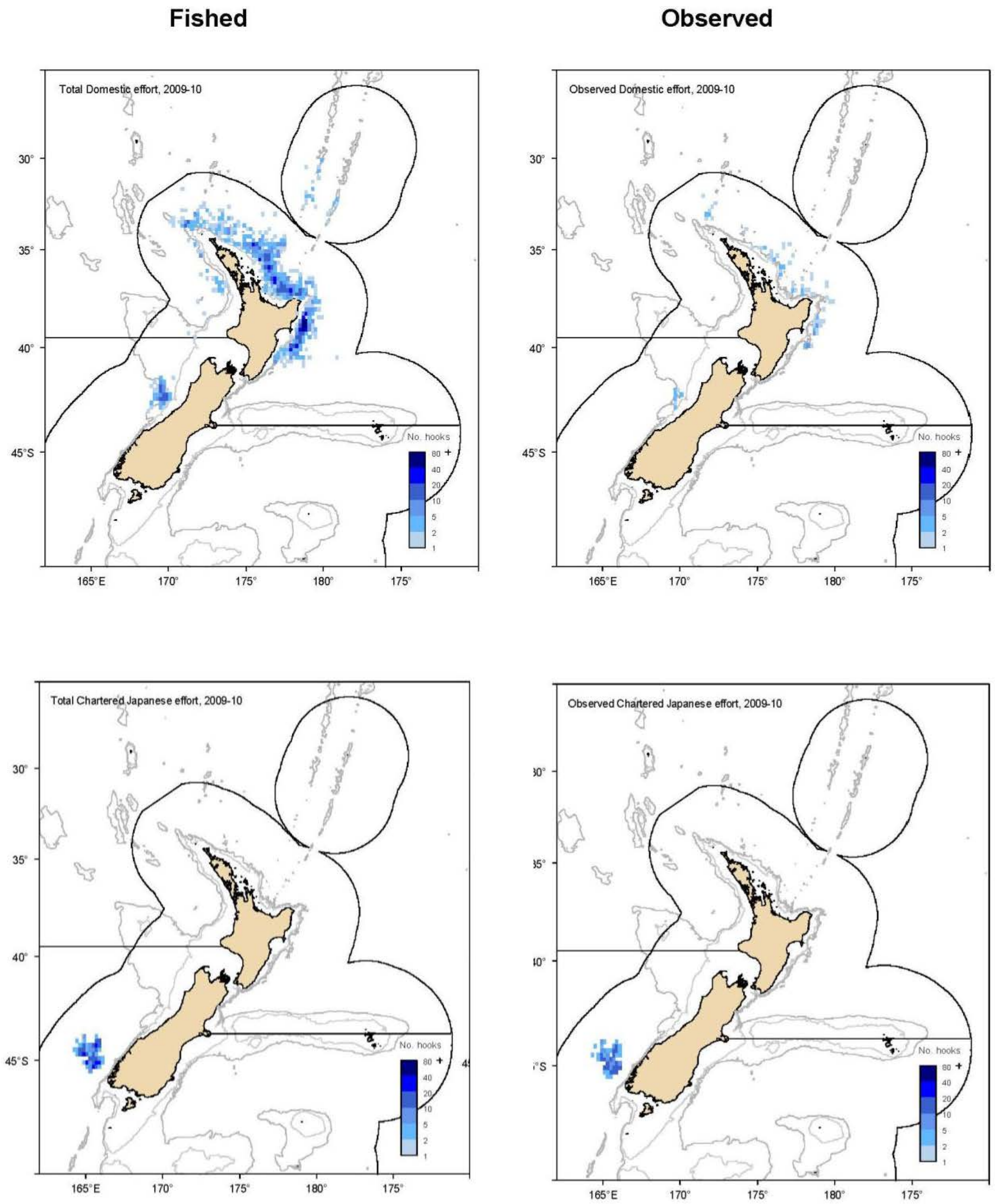


Figure 4: Distribution of fishing positions for the New Zealand domestic (top two panels) and charter (bottom two panels) vessels, for the 2009–10 fishing year, displaying both fishing effort (left) and observed effort (right).

1.2 Recreational fisheries

Recreational fishers make occasional catches of Pacific bluefin tuna. In 2004 a target recreational fishery developed off the west coast of the South Island targeting large Pacific bluefin tuna that feed on spawning aggregations of hoki (*Macruronus novaezealandiae*). Fish taken in this fishery have been submitted for various world records for this species. Some information on charter vessel catch was collected by MPI through voluntary reporting and in 2011 recreational charter boats were required to register and report catch and effort in this fishery. A small number of of private boats are also active in the fishery. The recreational allowance for Pacific bluefin was increased from 1 t to 25 t per year from 1 October 2011 to recognise the growth in this fishery. There is no information on the size of catch from the National Surveys of recreational fishers.

1.3 Customary non-commercial fisheries

There is no quantitative information available to allow the estimation of the harvest of Pacific bluefin tuna by customary fishers; however, the Maori customary catch of Pacific bluefin is probably negligible because of its seasonal and offshore distribution.

1.4 Illegal catch

There is no known illegal catch of Pacific bluefin tuna in New Zealand fisheries waters.

1.5 Other sources of mortality

There is likely to be a low level of shark damage and discard mortality of Pacific bluefin caught on tuna longlines that may be on the order of 1–2% assuming that all tuna species are subject to equivalent levels of incidental mortality. There have been reports that some fish hooked in the target recreational fishery have been lost due to entanglement of the fishing line with trawl warps. The survival of these lost fish is not known. An allowance of 3.5 t has been made for other sources of mortality.

2. BIOLOGY

Pacific bluefin tuna are epipelagic opportunistic predators of fish, crustaceans and cephalopods found within the upper few hundred meters of the water column. Individuals found in New Zealand fisheries waters are mostly adults. Adult Pacific bluefin occur broadly across the Pacific Ocean, especially the waters of the North Pacific Ocean.

There has been some uncertainty among fishers regarding bluefin tuna taken in New Zealand waters. Some fishers believe that three species of bluefin tuna are taken in New Zealand waters with some small catches of true “Northern” Atlantic tuna (*Thunnus thynnus*) in addition to Pacific and southern bluefin tuna. This belief is based on several factors including differences in morphology and the prices obtained for certain fish on the Japanese market.

To address this issue, muscle tissue samples were taken from 20 fish for which there was uncertainty as to whether the fish was a Pacific bluefin tuna (*Thunnus orientalis*) or an Atlantic bluefin tuna. A further sample from a fish thought to be a southern bluefin tuna was also included. The tissue samples were sequenced for the COI region of DNA, and the sequences compared with COI sequences for the three species of tuna held in GenBank. All of the DNA sequences, except one, matched with sequences for Pacific bluefin tuna. The final sample was confirmed as a southern bluefin tuna. Therefore, based on DNA analysis, there is presently no evidence that Atlantic bluefin tuna are taken in New Zealand waters. Further tissue samples from fish thought by fishers to be NTU will be collected by scientific observers.

Adult Pacific bluefin reach a maximum size of 550 kg and lengths of 300 cm. Maturity is reached at 3 to 5 years of age and individuals live to 15+ years old. Spawning takes place between Japan and the Philippines in April, May and June, spreading to the waters off southern Honshu in July and to the Sea of Japan in August. Pacific bluefin of 270 to 300 kg produce about 10 million eggs but there is no information on the frequency of spawning. Juveniles make extensive migrations north and eastwards across the Pacific Ocean as 1–2 year old fish. Pacific bluefin caught in the southern hemisphere, including those caught in New Zealand waters, are primarily adults.

Natural mortality is assumed to vary from about 0.1 to 0.4 and to be age specific in assessments undertaken by the IATTC. A range of von Bertalanffy growth parameters have been estimated for Pacific bluefin based on length frequency analysis, tagging and reading of hard parts (Table 4).

Table 4: von Bertalanffy growth parameters for Pacific bluefin tuna.

Method	L infinity	*k*	t_0
Length frequencies	300.0		
Scales	320.5	0.1035	- 0.7034
Scales	295.4		
Tagging	219.0	0.211	

The length weight relationship of Pacific bluefin based on observer data from New Zealand caught fish yields the following:

whole weight = $8.058\, e^{0.015\, length}$ $R^2 = 0.895$, n = 49 (weight is in kg and length is in cm).

Although the sample size of genetically confirmed Pacific bluefin that has been sexed by observers is small (50 fish), the sex ratio in New Zealand waters is not significantly different from 1:1.

3. STOCKS AND AREAS

Pacific bluefin tuna constitutes a single Pacific-wide stock that is primarily distributed in the northern hemisphere.

Between 2006 and 2008 42 Pacific bluefin were tagged from recreational charter vessels in New Zealand waters using Pop-off Satellite Archival Tags (PSATs), and all tags that have ‘reported’ indicate that these fish survived catch and release and spent several months within the New Zealand or Australian EEZs and adjacent waters over spring and summer. The full results of this work will be published in 2014. In addition 138 Pacific bluefin have been released with conventional tags. There have been four recaptures all from the West Coast recreational fishery. One fish was recaptured after 2 years 22 nautical miles from the release point and another after four years at liberty just 60 miles from where it was released. Both of these fish had carried PSAT tags.

4. ENVIRONMENTAL AND ECOSYSTEM CONSIDERATIONS

This section was updated for the November 2014 Fishery Assessment Plenary after review by the Aquatic Environment Working Group. This summary is from the perspective of pacific bluefin tuna but there is no directed fishery for them and the incidental catch sections below reflect the New Zealand longline fishery as a whole and are not specific to this species; a more detailed summary from an issue-by-issue perspective is available in the Aquatic Environment and Biodiversity Annual Review where the consequences are also discussed. (http://www.mpi.govt.nz/Default.aspx?TabId=126&id=2122) (Ministry for Primary Industries 2013a).

4.1 Role in the ecosystem

Pacific bluefin tuna (*Thunnus thynnus orientalis*,) is one of the largest teleost fish species (Kitagawa et al 2004), comprising a single population that spawns only to the south of Japan and in the Sea of Japan (Sund et al 1981). Pacific bluefin tuna are large pelagic predators, so they are likely to have a ‘top down’ effect on the fish, crustaceans and squid they feed on.

4.2 Incidental catch (seabirds, sea turtles and mammals)

The protected species capture estimates presented here include all animals recovered onto the deck (alive, injured or dead) of fishing vessels but do not include any cryptic mortality (e.g., seabirds caught on a hook but not brought onboard the vessel).

4.2.1 Seabird bycatch

Between 2002–03 and 2012–13, there were 818 observed captures of birds across other surface longline target fisheries (those not targeting albacore tuna, bigeye tuna, southern bluefin tuna, pacific bluefin tuna and swordfish).. Seabird capture rates since 2003 are presented in Table 5 and Figures 5 and 6. Seabird captures were more frequent off the south west coast of the South Island (Figure 7). Bayesian models of varying complexity dependent on data quality have been used to estimate captures across a range of methods (Richard & Abraham 2014). Observed and estimated seabird captures in albacore longline fisheries are provided in Table 6.

Through the 1990s the minimum seabird mitigation requirement for surface longline vessels was the use of a bird scaring device (tori line) but common practice was that vessels set surface longlines primarily at night. In 2007 a notice was implemented under s 11 of the Fisheries Act 1996 to formalise the requirement that surface longline vessels only set during the hours of darkness and use a tori line when setting. This notice was amended in 2008 to add the option of line weighting and tori line use if setting during the day. In 2011 the notices were combined and repromulgated under a new regulation (Regulation 58A of the Fisheries (Commercial Fishing) Regulations 2001) which provides a more flexible regulatory environment under which to set seabird mitigation requirements.

Risk posed by commercial fishing to seabirds has been assessed via a level 2 method which supports much of the NPOA-Seabirds 2013 risk assessment framework (MPI 2013b). The method used in the level 2 risk assessment arose initially from an expert workshop hosted by the Ministry of Fisheries in 2008. The overall framework is described in Sharp et al. (2011) and has been variously applied and improved in multiple iterations (Waugh et al. 2009, Richard et al. 2011, Richard and Abraham 2013, Richard et al. 2013 and Richard & Abraham in press). The method applies an "exposure-effects" approach where exposure refers to the number of fatalities is calculated from the overlap of seabirds with fishing effort compared with observed captures to estimate the species vulnerability (capture rates per encounter) to each fishery group. This is then compared to the population's productivity, based on population estimates and biological characteristics to yield estimates of population-level risk.

The 2014 iteration of the seabird risk assessment (Richard & Abraham in press) assessed other surface longline target fisheries (those not targeting albacore tuna, bigeye tuna, southern bluefin tuna, pacific bluefin tuna and swordfish) contribution to the total risk posed by New Zealand commercial fishing to seabirds (see Table 7). These target fisheries contribute 0.003 of PBR_1 to the risk to Southern Buller's albatross which was assessed to be at very high risk from New Zealand commercial fishing (Richard & Abraham in press).

Table 5: Number of observed seabird captures in the New Zealand surface longline fisheries, 2002–03 to 2012–13, by species and area. See glossary above for a description of the areas used for summarising the fishing effort and protected species captures. The risk ratio is an estimate of aggregate potential fatalities across trawl and longline fisheries relative to the Potential Biological Removals, PBR (from Richard and Abraham (2013) where full details of the risk assessment approach can be found). It is not an estimate of the risk posed by fishing for pacific bluefin tuna using longline gear but rather the total risk for each seabird species. Other data, version 20130305.

Albatross Species	Risk Ratio	Kermadec Islands	Northland and Hauraki	Bay of Plenty	East Coast North Island	Stewart Snares Shelf	Fiordland	West Coast South Island	West Coast North Island	Total
Salvin's	Very high	0	1	2	6	0	0	0	0	9
Southern Buller's	Very high	0	5	2	27	0	280	39	0	353
NZ white-capped	Very high	0	2	0	3	10	62	36	1	114
Northern Buller's	High	0	0	0	1	0	0	0	0	1
Gibson's	High	4	16	0	17	0	6	3	1	47
Antipodean	High	12	10	1	8	0	0	0	1	32
Northern royal	Medium	0	0	1	0	0	0	0	0	1
Southern royal	Medium	0	1	0	0	0	4	1	0	6
Campbell black-browed	Medium	2	10	2	29	0	3	3	1	50
Light-mantled sooty	Very low	0	0	0	0	0	0	1	0	1
Unidentified	N/A	38	2	0	2	0	0	0	1	43
Total	**N/A**	**56**	**47**	**8**	**93**	**10**	**355**	**83**	**5**	**657**

Other seabirds

	Risk Ratio	Kermadec Islands	Northland and Hauraki	Bay of Plenty	East Coast North Island	Stewart Snares Shelf	Fiordland	West Coast South Island	West Coast North Island	Total
Black petrel	Very high	1	10	1	0	0	0	0	1	13
Flesh-footed shearwater	Very high	0	0	0	10	0	0	0	2	12
Cape petrel	High	0	0	0	2	0	0	0	0	2
Westland petrel	Medium	0	0	0	2	0	1	6	0	9
White-chinned petrel	Medium	2	3	3	3	1	20	3	3	38
Grey petrel	Medium	3	4	3	38	0	0	0	0	48
Grey-faced petrel	Very low	12	5	1	2	0	0	0	0	20
Sooty shearwater	Very low	1	0	0	8	3	1	0	0	13
Southern giant petrel	-	0	0	2	0	0	0	0	2	0
White-headed petrel	-	2	0	0	0	0	0	0	0	2
Unidentified	N/A	0	1	0	0	0	1	0	0	2
Total	**N/A**	**21**	**23**	**10**	**65**	**4**	**23**	**9**	**8**	**159**

Table 6: Effort, observed and estimated seabird captures by fishing year for the New Zealand surface longline fishery within the EEZ. For each fishing year, the table gives the total number of hooks; the number of observed hooks; observer coverage (the percentage of hooks that were observed); the number of observed captures; the capture rate (captures per thousand hooks); and the mean number of estimated total captures (with 95% confidence interval). Estimates are based on methods described in Thompson et al (2013) and are available via http://www.fish.govt.nz/en-nz/Environmental/Seabirds/. Estimates from 2002–03 to 2010–11 and preliminary estimates for 2012–13 are based on data version 20140131.

			Fishing effort	Observed captures		Estimated captures	
Fishing year	All hooks	Observed hooks	% observed	Number	Rate	Mean	95% c.i.
2002–2003	10 772 188	2 195 152	20.4	115	0.052	2 088	1 613–2 807
2003–2004	7 386 329	1 607 304	21.8	71	0.044	1 395	1 086–1 851
2004–2005	3 679 765	783 812	21.3	41	0.052	617	483–793
2005–2006	3 690 119	705 945	19.1	37	0.052	808	611–1 132
2006–2007	3 739 912	1 040 948	27.8	187	0.18	958	736–1 345
2007–2008	2 246 189	421 900	18.8	37	0.088	524	417–676
2008–2009	3 115 633	937 496	30.1	57	0.061	609	493–766
2009–2010	2 995 264	665 883	22.2	135	0.203	939	749–1 216
2010–2011	3 187 879	674 572	21.2	47	0.07	705	532–964
2011–2012	3 100 277	728 190	23.5	64	0.088	829	617–1 161
2012–2013†	2 862 182	560 333	19.6	27	0.048	783	567–1 144

†Provisional data, model estimates not finalised.

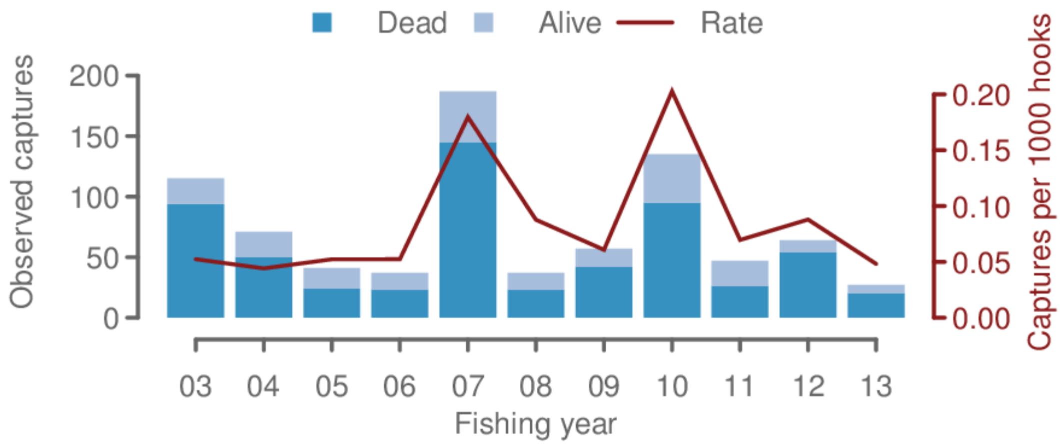


Figure 5: Observed captures of seabirds in the New Zealand surface longline fisheries from 2002–03 to 2012–13.

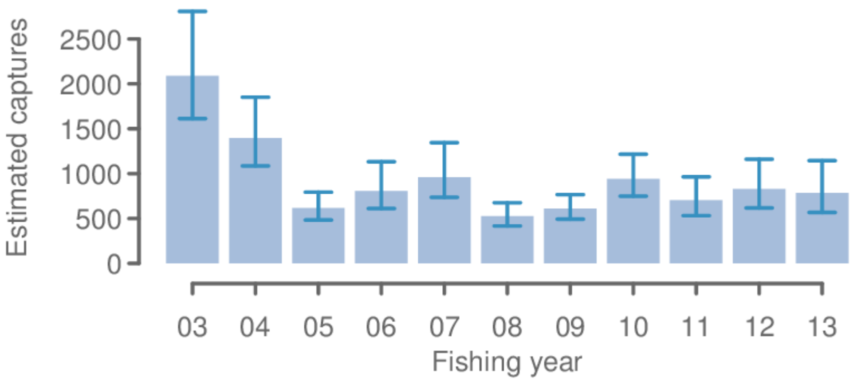


Figure 6: Estimated captures of seabirds in the New Zealand surface longline fisheries from 2002–03 to 2012–13.

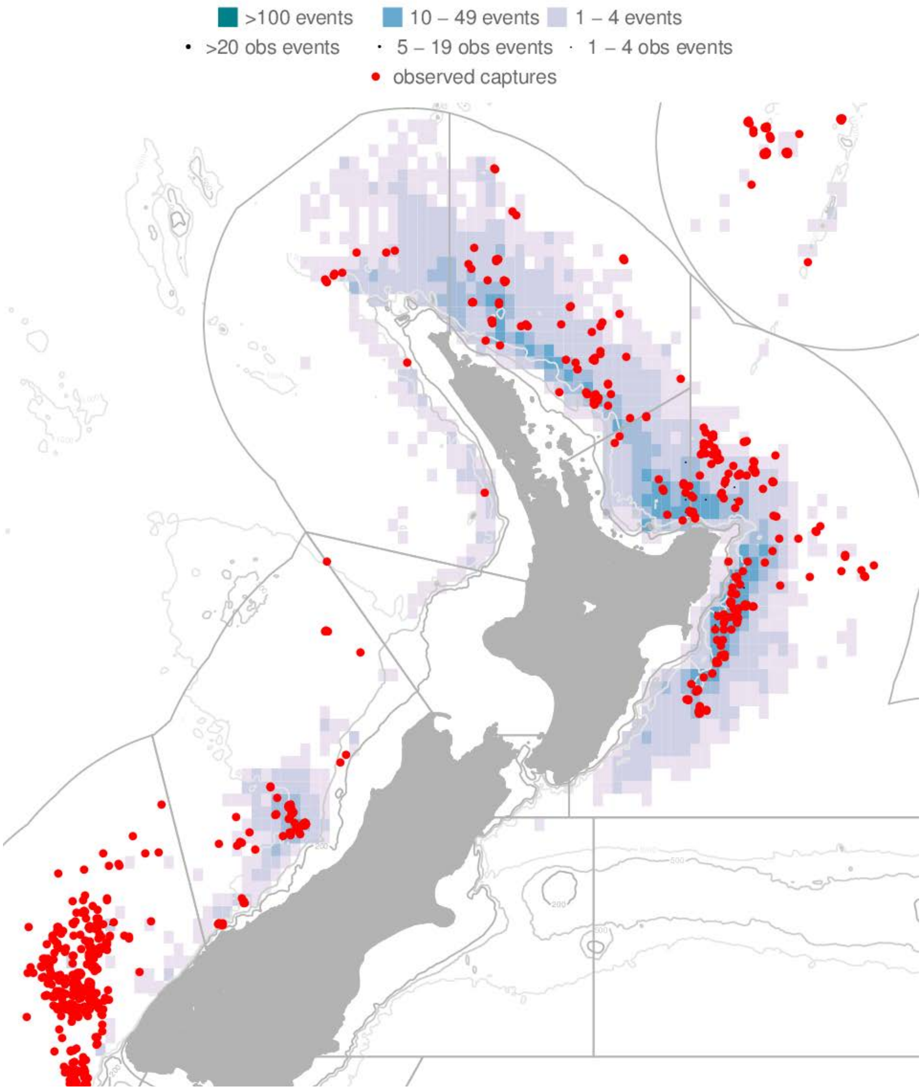


Figure 7: Distribution of fishing effort in the New Zealand surface longline fisheries and observed seabird captures, 2002–03 to 2012–13. Fishing effort is mapped into 0.2-degree cells, with the colour of each cell being related to the amount of effort. Observed fishing events are indicated by black dots, and observed captures are indicated by red dots. Fishing is only shown if the effort could be assigned a latitude and longitude, and if there were three or more vessels fishing within a cell. In this case, 89.4% of the effort is shown. See glossary for areas used for summarising the fishing effort and protected species captures.

Table 7: Risk ratio of seabirds predicted by the level two risk assessment for the other species target surface longline fisheries (those not targeting albacore tuna, bigeye tuna, southern bluefin tuna, pacific bluefin tuna and swordfish) and all fisheries included in the level two risk assessment, 2006–07 to 2012–13, showing seabird species with risk category of very or high, or a medium risk category and risk ratio of at least 1% of the total risk. The risk ratio is an estimate of aggregate potential fatalities across trawl and longline fisheries relative to the Potential Biological Removals, PBR_1 (from Richard and Abraham 2014 where full details of the risk assessment approach can be found). PBR_1 applies a recovery factor of 1.0. Typically a recovery factor of 0.1 to 0.5 is applied (based on the state of the population) to allow for recovery from low population sizes as quickly as possible. This should be considered when interpreting these results. The New Zealand threat classifications are shown (Robertson et al 2013 at http://www.doc.govt.nz/documents/science-and-technical/nztcs4entire.pdf)

	Risk ratio				
Species name	OTH target SLL	Total risk from NZ commercial fishing	% of total risk from NZ commercial fishing	Risk category	NZ Threat Classification
Black petrel	0.000	15.095	0.00	Very high	Threatened: Nationally Vulnerable
Salvin's albatross	0.000	3.543	0.00	Very high	Threatened: Nationally Critical
Southern Buller's albatross	0.003	2.823	0.10	Very high	At Risk: Naturally Uncommon
Flesh-footed shearwater	0.000	1.557	0.00	Very high	Threatened: Nationally Vulnerable
Gibson's albatross	0.000	1.245	0.00	Very high	Threatened: Nationally Critical
New Zealand white-capped albatross	0.000	1.096	0.01	Very high	At Risk: Declining
Chatham Island albatross	0.000	0.913	0.00	High	At Risk: Naturally Uncommon
Antipodean albatross	0.000	0.888	0.00	High	Threatened: Nationally Critical
Westland petrel	0.000	0.498	0.00	High	At Risk: Naturally Uncommon
Northern Buller's albatross	0.000	0.336	0.13	High	At Risk: Naturally Uncommon
Campbell black-browed albatross	0.000	0.304	0.00	High	At Risk: Naturally Uncommon
Stewart Island shag	0.000	0.301	0.00	High	Threatened: Nationally Vulnerable

4.2.2 Sea turtle bycatch

Between 2002–03 and 2012–13, there were 15 observed captures of sea turtles across all surface longline fisheries (Tables 7 and 9, Figure 8). Observer records documented all but one sea turtle as captured and released alive. Sea turtle capture distributions predominantly occur throughout the east coast of the North Island and Kermadec Island fisheries (Figure 9).

Table 8: Number of observed sea turtle captures in the New Zealand surface longline fisheries, 2002–03 to 2012–13, by species and area. Data from Thompson et al (2013), retrieved from http://data.dragonfly.co.nz/psc/. See glossary above for a description of the areas used for summarising the fishing effort and protected species captures.

Species	Bay of Plenty	East Coast North Island	Kermadec Islands	West Coast North Island	Total
Leatherback turtle	1	4	3	3	11
Green turtle	0	1	0	0	1
Unknown turtle	0	1	0	2	3
Total	1	6	3	5	15

Table 9: Effort and sea turtle captures in surface longline fisheries by fishing year. For each fishing year, the table gives the total number of hooks; the number of observed hooks; observer coverage (the percentage of hooks that were observed); the number of observed captures (both dead and alive); and the capture rate (captures per thousand hooks). For more information on the methods used to prepare the data see Thompson et al (2013).

	Fishing effort			Observed captures	
Fishing year	All hooks	Observed hooks	% observed	Number	Rate
2002–2003	10 772 188	2 195 152	20.4	0	0
2003–2004	7 386 329	1 607 304	21.8	1	0.001
2004–2005	3 679 765	783 812	21.3	2	0.003
2005–2006	3 690 119	705 945	19.1	1	0.001
2006–2007	3 739 912	1 040 948	27.8	2	0.002
2007–2008	2 246 189	421 900	18.8	1	0.002
2008–2009	3 115 633	937 496	30.1	2	0.002
2009–2010	2 995 264	665 883	22.2	0	0
2010–2011	3 187 879	674 572	21.2	4	0.006
2011–2012	3 100 277	728 190	23.5	0	0
2012–2013	2 862 182	560 333	19.6	2	0.004

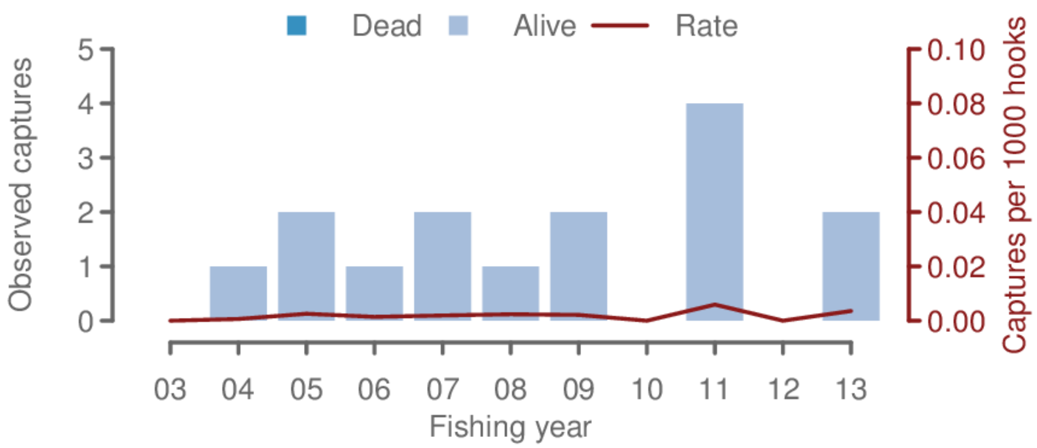


Figure 8: Observed captures of sea turtles in the New Zealand surface longline fisheries from 2002–03 to 2012–13.

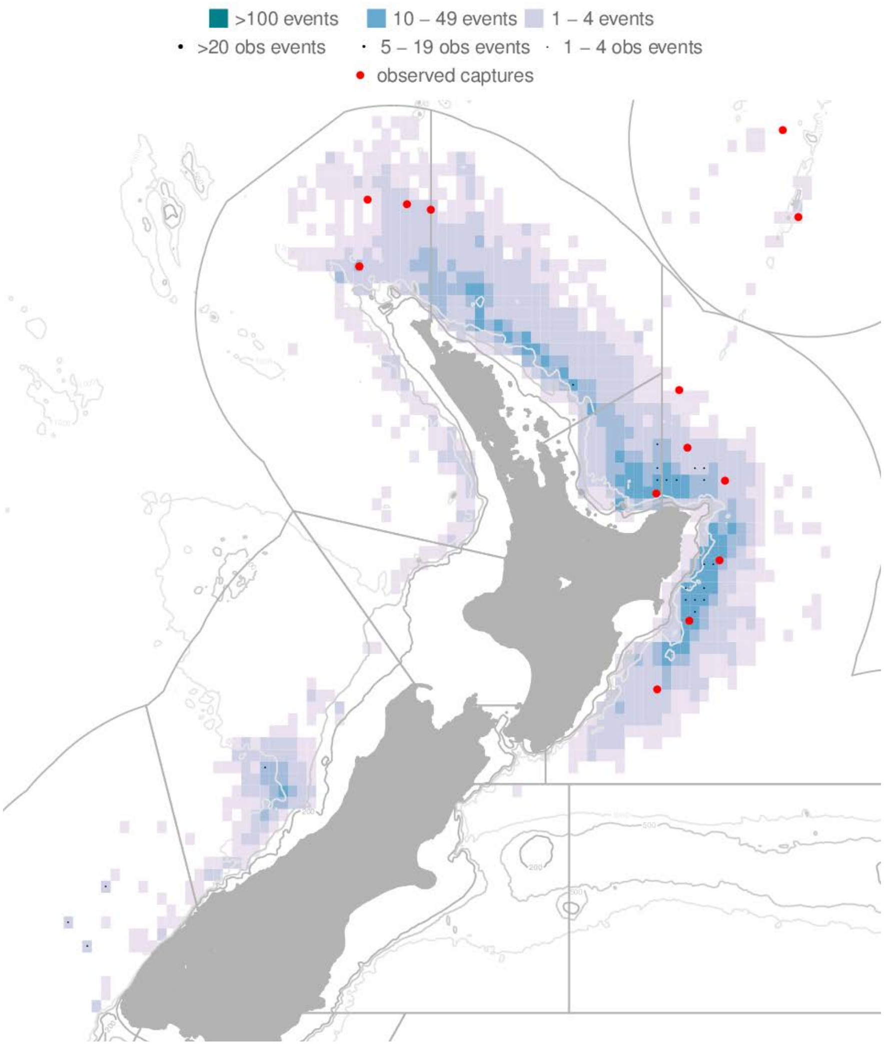


Figure 9: Distribution of fishing effort in the New Zealand surface longline fisheries and observed sea turtle captures, 2002–03 to 2012–13. Fishing effort is mapped into 0.2-degree cells, with the colour of each cell being related to the amount of effort. Observed fishing events are indicated by black dots, and observed captures are indicated by red dots. Fishing is only shown if the effort could be assigned a latitude and longitude, and if there were three or more vessels fishing within a cell. In this case, 89.4% of the effort is shown. See glossary for areas used for summarising the fishing effort and protected species captures.

4.2.3 Marine Mammals

4.2.3.1 Cetaceans

Cetaceans are dispersed throughout New Zealand waters (Perrin et al 2008). The spatial and temporal overlap of commercial fishing grounds and cetacean foraging areas has resulted in cetacean captures in fishing gear (Abraham & Thompson 2009, 2011).

Between 2002–03 and 2012–13, there were seven observed captures of whales and dolphins in surface longline fisheries. Observed captures included 5 unidentified cetaceans and 2 long-finned Pilot whales (Tables 10 and 11, Figure 10) (Thompson et al 2013). All captured animals recorded were documented as being caught and released alive (Thompson et al 2013). Cetacean capture distributions are more frequent off the east coast of the North Island (Figure 11).

Table 10: Number of observed cetacean captures in the New Zealand surface longline fisheries, 2002–03 to 2012–13, by species and area. Data from Thompson et al (2013), retrieved from http://data.dragonfly.co.nz/psc/. See glossary above for a description of the areas used for summarising the fishing effort and protected species captures.

Species	Bay of Plenty	East Coast North Island	Fiordland	Northland and Hauraki	West Coast North Island	West Coast South Island	Total
Long-finned pilot whale	0	1	0	0	0	1	2
Unidentified cetacean	1	1	1	1	1	0	5
Total	1	2	1	1	1	1	7

Table 11: Effort and captures of cetaceans in surface longline fisheries by fishing year. For each fishing year, the table gives the total number of hooks; the number of observed hooks; observer coverage (the percentage of hooks that were observed); the number of observed captures (both dead and alive); and the capture rate (captures per thousand hooks). For more information on the methods used to prepare the data, see Thompson et al (2013).

	Fishing effort			Observed captures	
Fishing year	All hooks	Observed hooks	% observed	Number	Rate
2002–2003	10 772 188	2 195 152	20.4	1	0
2003–2004	7 386 329	1 607 304	21.8	4	0.002
2004–2005	3 679 765	783 812	21.3	1	0.001
2005–2006	3 690 119	705 945	19.1	0	0
2006–2007	3 739 912	1 040 948	27.8	0	0
2007–2008	2 246 189	421 900	18.8	1	0.002
2008–2009	3 115 633	937 496	30.1	0	0
2009–2010	2 995 264	665 883	22.2	0	0
2010–2011	3 187 879	674 572	21.2	0	0
2011–2012	3 100 277	728 190	23.5	0	0
2012–2013	2 862 182	560 333	19.6	0	0

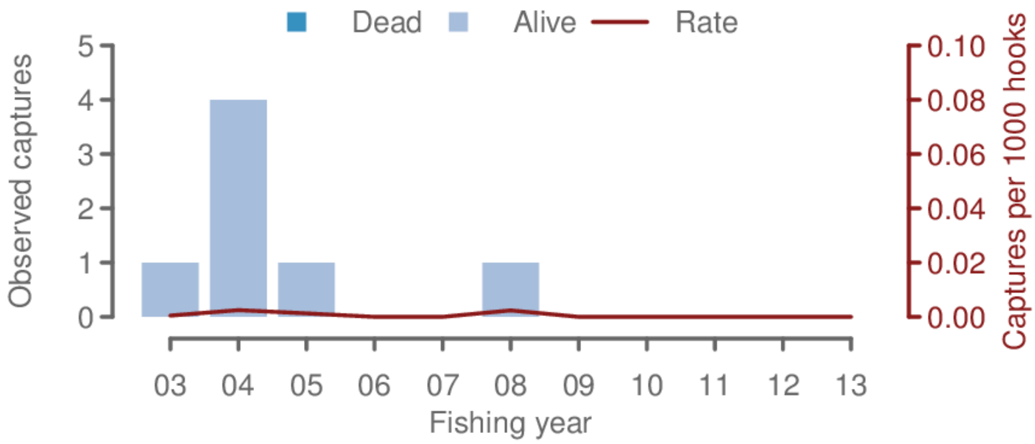


Figure 10: Observed captures of cetaceans in the New Zealand surface longline fisheries from 2002–03 to 2012–13.

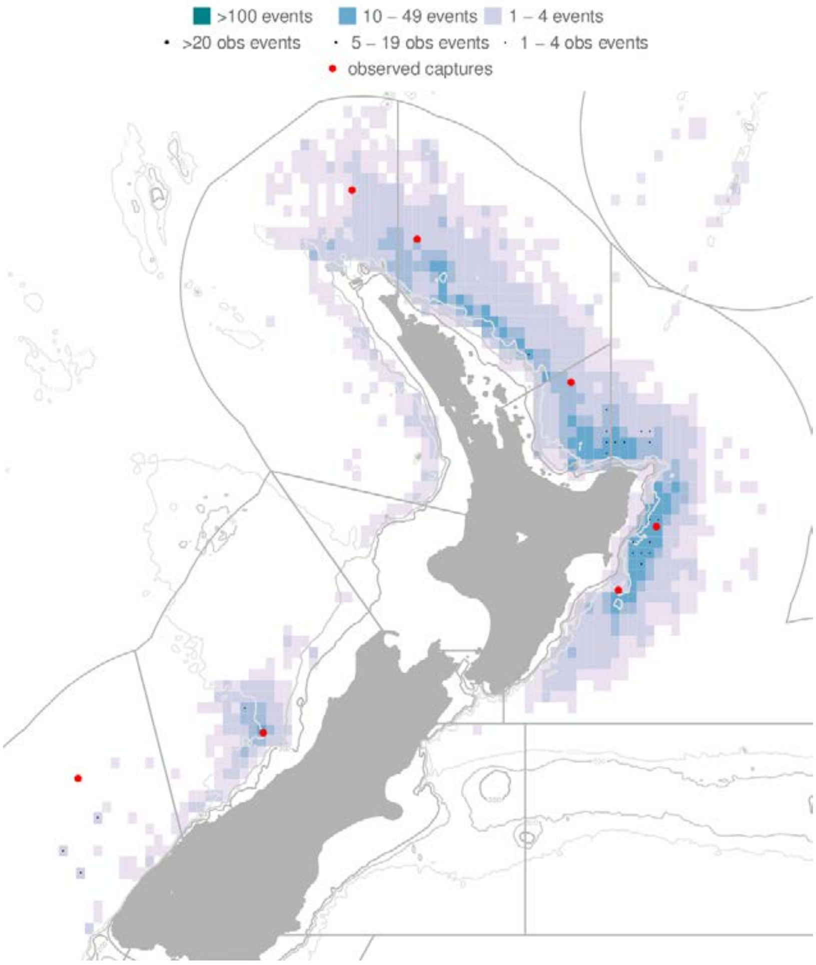


Figure 11: Distribution of fishing effort in the New Zealand surface longline fisheries and observed cetacean captures, 2002–03 to 2012–13. Fishing effort is mapped into 0.2-degree cells, with the colour of each cell being related to the amount of effort. Observed fishing events are indicated by black dots, and observed captures are indicated by red dots. Fishing is only shown if the effort could be assigned a latitude and longitude, and if there were three or more vessels fishing within a cell. In this case, 89.4% of the effort is shown. See glossary for areas used for summarising the fishing effort and protected species captures.

4.2.3.2 New Zealand fur seal bycatch

Currently, New Zealand fur seals are dispersed throughout New Zealand waters, especially in waters south of about 40º S to Macquarie Island. The spatial and temporal overlap of commercial fishing grounds and New Zealand fur seal foraging areas has resulted in New Zealand fur seal captures in fishing gear (Mattlin 1987, Rowe 2009). Most fisheries with observed captures occur in waters over or close to the continental shelf, which slopes steeply to deeper waters relatively close to shore, and thus rookeries and haulouts, around much of the South Island and offshore islands. Captures on longlines occur when the fur seals attempt to feed on the bait and fish catch during hauling. Most New Zealand fur seals are released alive, typically with a hook and short snood or trace still attached.

New Zealand fur seal captures in surface longline fisheries have been generally observed in waters south and west of Fiordland, but also in the Bay of Plenty-East Cape area when the animals have attempted to take bait or fish from the line as it is hauled. These capture rates include animals that are released alive (100% of observed surface longline capture in 2008–09; Thompson & Abraham 2010). Capture rates in 2011–12 and 2012-13 were higher than they were in the early 2000s (Figures 12 and 13). While fur seal captures have occurred throughout the range of this fishery most New Zealand captures have occurred off the Southwest coast of the

South Island (Figure 14). Between 2002–03 and 2012–13, there were 267 observed captures of New Zealand fur seal in surface longline fisheries (Tables 12 and 13).

Table 12: Number of observed New Zealand fur seal captures in the New Zealand surface longline fisheries, 2002–03 to 2012–13, by species and area. Data from Thompson et al (2013), retrieved from http://data.dragonfly.co.nz/psc/. See glossary above for a description of the areas used for summarising the fishing effort and protected species captures.

	Bay of Plenty	East Coast North Island	Fiordland	Northland and Hauraki	Stewart Snares Shelf	West Coast North Island	West Coast South Island	Total
New Zealand fur seal	11	33	179	4	4	2	34	267

Table 13: Effort and captures of New Zealand fur seal in the New Zealand surface longline fisheries by fishing year. For each fishing year, the table gives the total number of hooks; the number of observed hooks; observer coverage (the percentage of hooks that were observed); the number of observed captures (both dead and alive); and the capture rate (captures per thousand hooks). Data from Thompson et al (2013), retrieved from http://data.dragonfly.co.nz/psc/. Estimates from 2002–03 to 2010–11 and preliminary estimates for 2012–13 are based on data version 20140131.

	Fishing effort			Observed captures		Estimated captures	
Fishing year	All hooks	Observed hooks	% observed	Number	Rate	Mean	95% c.i.
2002–2003	10 772 188	2 195 152	20.4	56	0.026	299	199–428
2003–2004	7 386 329	1 607 304	21.8	40	0.025	134	90–188
2004–2005	3 679 765	783 812	21.3	20	0.026	66	38–99
2005–2006	3 690 119	705 945	19.1	12	0.017	47	23–79
2006–2007	3 739 912	1 040 948	27.8	10	0.010	32	14–55
2007–2008	2 246 189	421 900	18.8	10	0.024	40	19–68
2008–2009	3 115 633	937 496	30.1	22	0.023	53	29–81
2009–2010	2 995 264	665 883	22.2	19	0.029	77	43–121
2010–2011	3 187 879	674 572	21.2	17	0.025	64	35–101
2011–2012	3 100 277	728 190	23.5	40	0.055	140	92–198
2012–2013†	2 862 182	560 333	19.6	21	0.037	110	65–171

†Provisional data, model estimates not finalised.

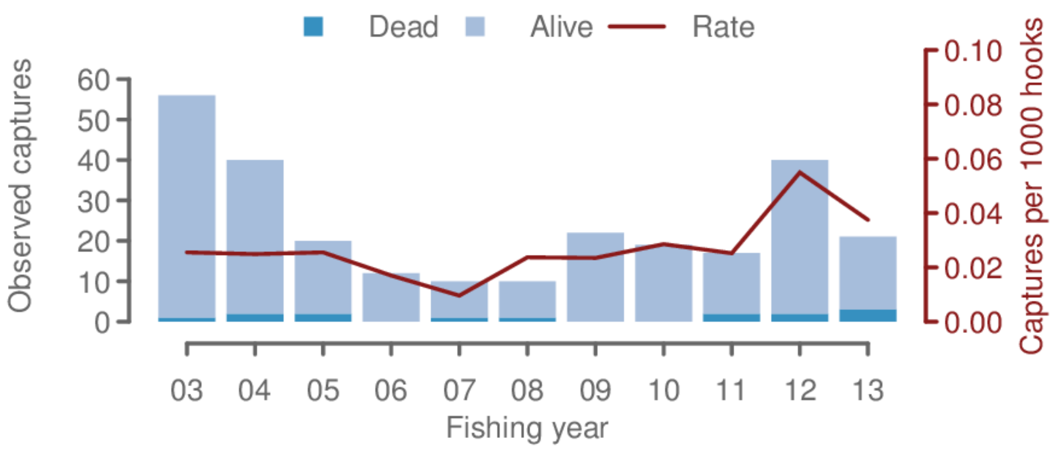


Figure 12: Observed captures of New Zealand fur seal in the New Zealand surface longline fisheries from 2002–03 to 2012–13.

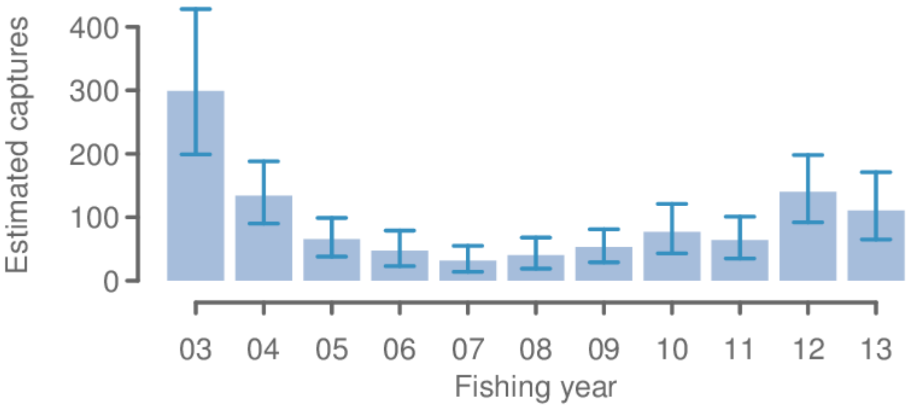


Figure 13: Estimated captures of New Zealand fur seal in the New Zealand surface longline fisheries from 2002–03 to 2012–13.

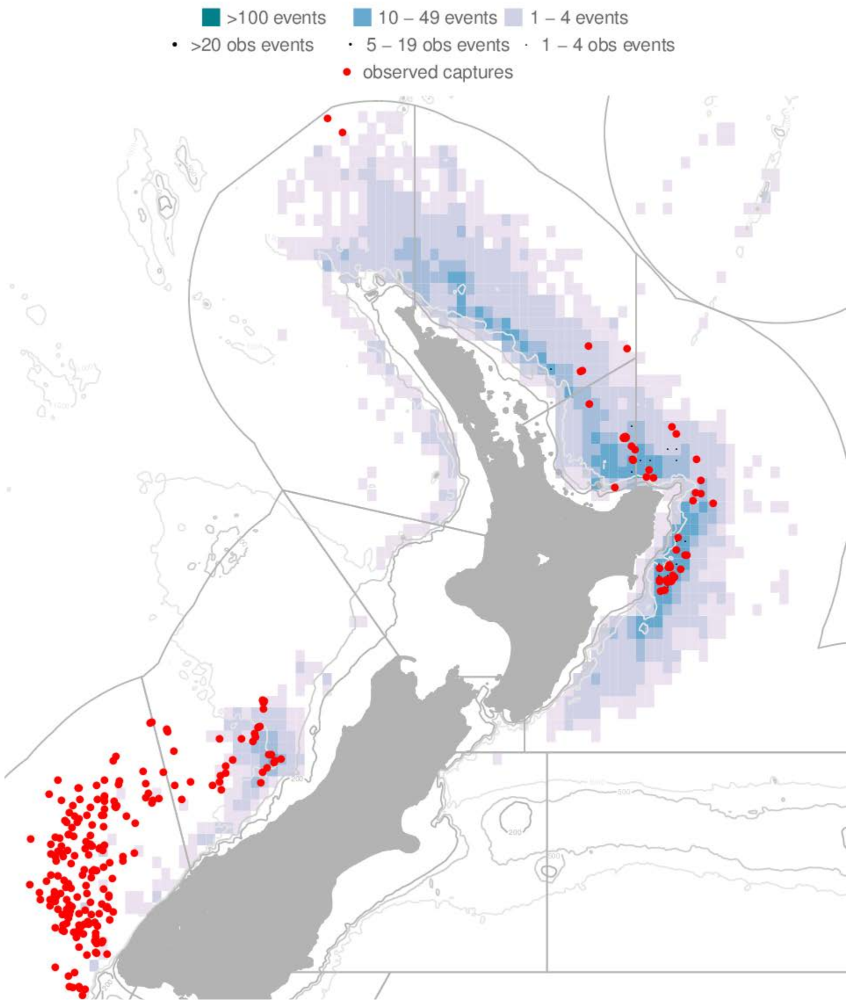


Figure 14: Distribution of fishing effort in the New Zealand surface longline fisheries and observed New Zealand fur seal captures, 2002–03 to 2012–13. Fishing effort is mapped into 0.2-degree cells, with the colour of each cell being related to the amount of effort. Observed fishing events are indicated by black dots, and observed captures are indicated by red dots. Fishing is only shown if the effort could be assigned a latitude and longitude, and if there were three or more vessels fishing within a cell. In this case, 89.4% of the effort is shown. See glossary for areas used for summarising the fishing effort and protected species captures.

4.3 Incidental fish bycatch

Observer records indicate that a wide range of species are landed by the longline fleets in New Zealand fishery waters. Blue sharks are the most commonly landed species (by number), followed by Ray's bream (Table 14). Southern bluefin tuna and albacore tuna are the only target species that occur in the top five of the frequency of occurrence.

Table 14: Total estimated catch (numbers of fish) of common bycatch species in the New Zealand longline fishery as estimated from observer data from 2009 to 2013. Also provided is the percentage of these species retained (2013 data only) and the percentage of fish that were alive when discarded, N/A (none discarded).

Species	2010	2011	2012	2013	% retained (2013)	discards % alive (2013)
Blue shark	66113	53432	132925	158736	45.2	97.4
Lancetfish	43425	37305	7866	19172	0.1	37.6
Rays bream	20041	18453	19918	13568	97.4	4.2
Porbeagle shark	4679	9929	7019	9805	34.0	79.8
Mako shark	4490	9770	3902	3981	35.5	84.9
Moonfish	5398	3418	2363	2470	99.0	0.0
Escolar	1539	6602	2181	2088	30.2	76.3
Sunfish	3148	3773	3265	1937	2.7	100.0
Pelagic stingray	1983	4090	712	1199	1.0	97.0
Butterfly tuna	1158	909	713	1030	48.1	11.1
Deepwater dogfish	377	548	647	743	1.2	88.5
Oilfish	886	1747	509	386	26.5	72.2
Rudderfish	326	338	491	362	13.0	80.0
Thresher shark	209	349	246	256	33.3	75.0
Skipjack tuna	91	255	123	240	100.0	N/A
Dealfish	1160	223	372	237	1.7	25.1
Striped marlin	471	175	124	182	0.0	44.4
Big scale pomfret	505	139	108	67	88.2	100.0
School shark	62	49	477	21	100.0	N/A

4.4 Benthic interactions

N/A

4.5 Key environmental and ecosystem information gaps

Cryptic mortality is unknown at present but developing a better understanding of this in future may be useful for reducing uncertainty of the seabird risk assessment and could be a useful input into risk assessments for other species groups.

The survival rates of released target and bycatch species is currently unknown.

Observer coverage in the New Zealand fleet is not spatially and temporally representative of the fishing effort.

5. STOCK ASSESSMENT

No assessment is possible for Pacific bluefin tuna within the New Zealand fishery waters as the proportion of the greater stock found within these waters is unknown and is likely to vary from year to year.

The update of the stock assessment of Pacific bluefin was outlined in WCPFC-SC10-2014/SA-WP-11. Results of the 2014 stock assessment are summarized as follows. The update of the stock assessment was completed in February 2014 at the SWSFC in La Jolla, USA through updates of fishery data up to June 2013 according to a request from the 2013 ISC Plenary. The fishery data (quarterly catch, size composition) from 1952 to 2010 (July 1952-June 2011) used in the 2012 stock assessment were not changed. In the case of CPUE time series, due to the nature of the CPUE standardizations method, the whole time series will need to be re-standardized with the additional two years of data. Stock Synthesis v3.23b was used as stock assessment model. Future projections were conducted under the 7 harvesting scenarios assigned by NC9. The software used for the future projections is distributed as an R-package named 'ssfuture'.

The current (2012) spawning stock biomass was 26,324 mt and slightly higher than that estimated for 2010 (25,476 mt). Mean recruitment for the last five years may have been below the historical average level. Although no target or LRPs have been established for the PBF stock, the current F average over 2009-2011 exceeds all target and limit biological reference points (BRPs) commonly used by fisheries managers except for F_{loss}, and the ratio of SSB in 2012 relative to unfished SSB (depletion ratio) is less than 6%. Based on reference point ratios, overfishing is occurring and the stock is overfished. Based on projection results, adopted WCPFC CMM (2013-09) and IATTC resolution for 2014 (C-13-02), if continued, are not expected to increase SSB if recent low recruitment continues. In relation to the projections "requested" by NC9, only Scenario 6, the strictest one, results in an increase in SSB even if the current low recruitment continues. If the low recruitment of recent years continues the risk of SSB falling below its historically lowest level observed would increase. This risk can be reduced with implementation of more conservative management measures.

SC10 noted that the ISC provided the following conclusions on the stock status of Pacific bluefin tuna in the Pacific Ocean in 2014:

- Using the updated stock assessment, the 2012 SSB was 26,324 mt and slightly higher than that estimated for 2010 (25,476 mt).

- Across sensitivity runs in the update stock assessment, estimates of recruitment were considered robust. The recruitment level in 2012 was estimated to be relatively low (the 8th lowest in 61 years), and the average recruitment level for the last five years may have been below the historical average level (Figure B1). Estimated age-specific fishing mortalities on the stock in the period 2009-2011 relative to 2002-2004 (the base period for WCPFC Conservation and Management Measure 2010-04) increased by 19%, 4%, 12%, 31%, 60%, 51% and 21% for ages 0-6, respectively, and decreased by 35% for age 7+ (Figure B2).

- Although no target or LRPs have been established for the PBF stock under the auspices of the WCPFC and IATTC, the current *F* average over 2009-2011 exceeds all target and limit biological reference points (BRPs) commonly used by fisheries managers except for *Floss*, and the ratio of SSB in 2012 relative to unfished SSB (depletion ratio) is less than 6%. In summary, based on reference point ratios, overfishing is occurring and the stock is overfished (Table 15).

Table 15: Ratio of the estimated fishing mortalities $F_{2002\text{-}2004}$, $F_{2007\text{-}2009}$ and $F_{2009\text{-}2011}$ relative to computed *F*-based biological reference points for Pacific bluefin tuna (*Thunnus orientalis*) and depletion ratio (ratio of SSB in 2012 relative to unfished SSB), and estimated SSB (mt) in year 2012. Values in the first eight columns above 1.0 indicate overfishing.

	F_{Max}	$F_{0.1}$	F_{Med}	F_{loss}	$F_{10\%}$	$F_{20\%}$	$F_{30\%}$	$F_{40\%}$
$F_{2002\text{-}2004}$	1.70	2.44	1.09	0.84	1.16	1.68	2.26	2.98
$F_{2007\text{-}2009}$	2.09	2.96	1.40	1.08	1.48	2.14	2.87	3.79
$F_{2009\text{-}2011}$	1.79	2.54	1.25	0.97	1.32	1.90	2.55	3.36

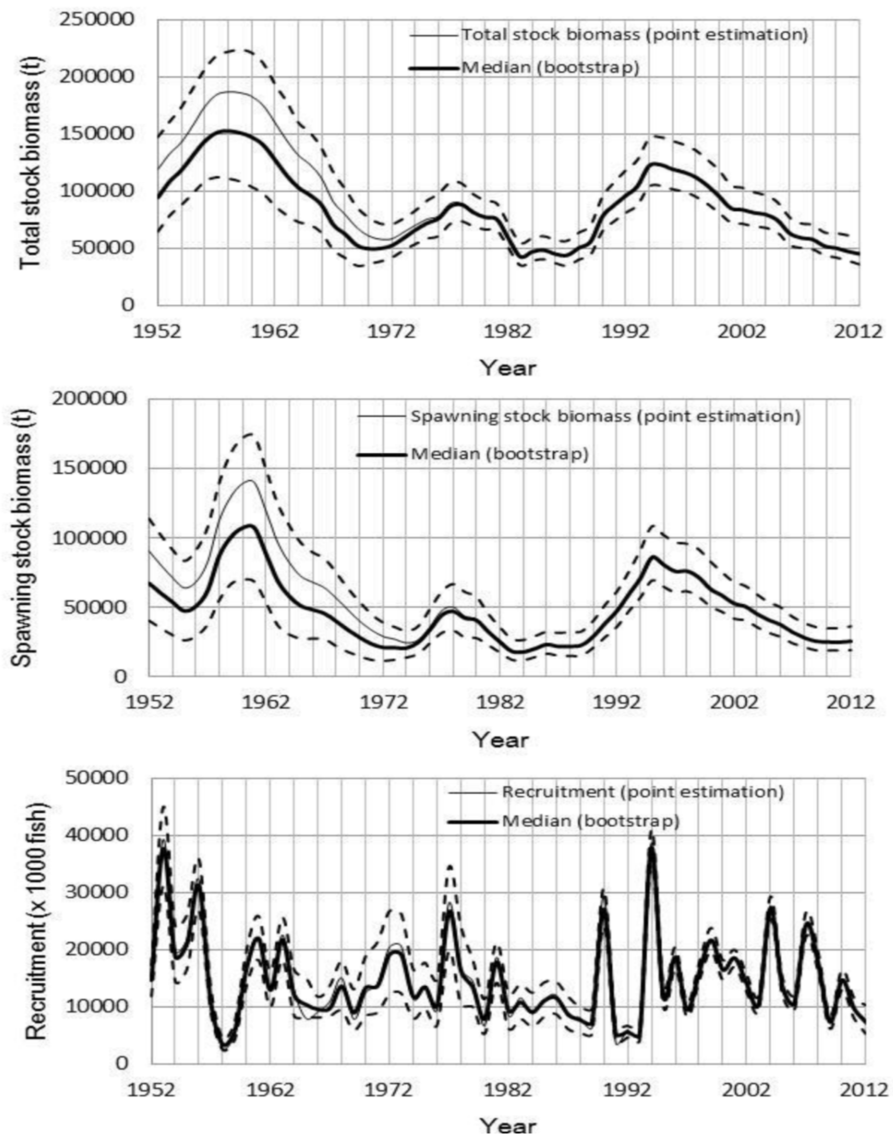


Figure 15. Total stock biomass, spawning stock biomass, and recruitment from 1952 to 2012.

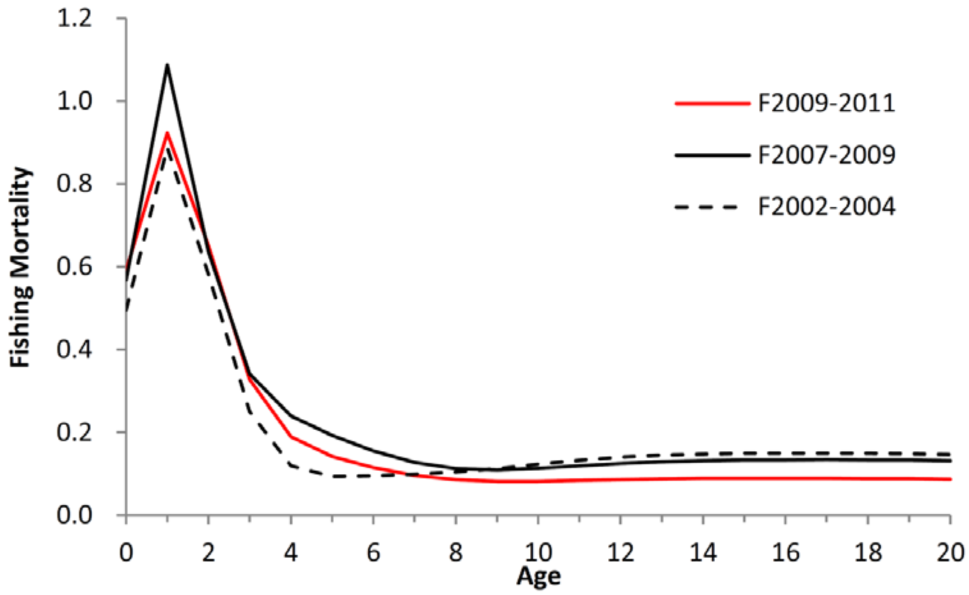


Figure 16. Geometric mean annual age-specific Pacific bluefin tuna (*Thunnus orientalis*) fishing mortalities for 2002-2004 (dashed line), 2007-2009 (solid line) and 2009-2011 (red line)

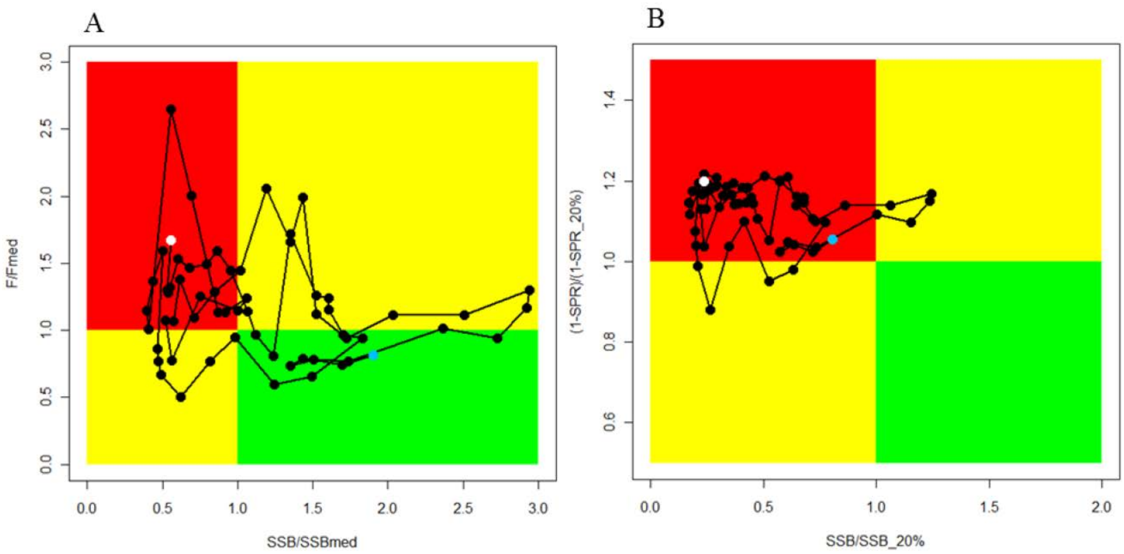


Figure 17. Alternative Kobe plots for Pacific bluefin tuna (*Thunnus orientalis*). A. *SSBMED* and *FMED*; B. *SSB20%* and *SPR20%.* Citation of these Kobe plots should include clarifying comments in the text. The blue and white points on the plot show the start (1952) and end (2012) year of the period modeled in the stock assessment, respectively.

Management advice and implications

SC10 noted that the ISC provided the following conservation advice from ISC:

- The current (2012) PBF biomass level is near historically low levels and experiencing high exploitation rates above all biological reference points except for F_{loss}. Based on projection results, the recently adopted WCPFC CMM (2013-09) and IATTC resolution for 2014 (C-13-02) if continued in to the future, are not expected to increase SSB if recent low recruitment continues.

- In relation to the projections requested by NC9, only Scenario 6, the strictest one, results in an increase in SSB even if the current low recruitment continues. Given the result of Scenario 6, further substantial reductions in fishing mortality and juvenile catch over the whole range of juvenile ages should be considered to reduce the risk of SSB falling below its historically lowest level.

- If the low recruitment of recent years continues the risk of SSB falling below its historically lowest level observed would increase. This risk can be reduced with implementation of more conservative management measures.

- Based on the results of future projections requested at NC9, unless the historical average level (1952-2011) of recruitment is realized, an increase of SSB cannot be expected under the current WCPFC and IATTC conservation and management measures, even under full implementation (Scenario 1).

- If the specifications of the harvest control rules used in the projections were modified to include a definition of juveniles that is more consistent with the maturity ogive used in the stock assessment, projection results could be different; for example, rebuilding may be faster. While no projection with a consistent definition of juvenile in any harvest scenario was conducted, any proposed reductions in juvenile catch should consider all non-mature individuals.

- Given the low level of SSB, uncertainty in future recruitment, and importance of recruitment in influencing stock biomass, monitoring of recruitment should be strengthened to allow the trend of recruitment to be understood in a timely manner.

5.1 Estimates of fishery parameters and abundance
None are available at present.

5.2 Biomass estimates
Estimates of current and reference biomass are not available.

5.3 Yield estimates and projections
No estimates of *MCY* and *CAY* are available.

6. STATUS OF THE STOCKS

Stock structure assumptions
Western and Central Pacific Ocean
All biomass in this Table refer to spawning biomass (SB).

Stock Status	
Year of Most Recent Assessment	2014
Assessment Runs Presented	Base case model
Reference Points	Target: Not established; default = B_{MSY} Soft Limit: Not established by WCPFC or IATTC; but evaluated using HSS default of 20% SB_0 Hard Limit: Not established by WCPFC or IATTC; but evaluated using HSS default of 10% SB_0 Overfishing threshold: F_{MSY}
Status in relation to Target	Very Unlikely (< 10%) to be at or above B_{MSY} Very Unlikely (< 10%) that $F < F_{MSY}$
Status in relation to Limits	Very Likely (> 90%) to be below the Soft Limit Very Likely (> 90%) to be below the Hard Limit
Status in relation to Overfishing	Overfishing is Very Likely (> 90%) to be occurring
Historical Stock Status Trajectory and Current Status	

Fishery and Stock Trends	
Recent Trend in Biomass or Proxy	Biomass is close to the lowest level ever experienced.
Recent Trend in Fishing Intensity or Proxy	F's on recruits (age 0) and on juveniles (ages 1–3) have been generally increasing for more than a decade (1990–2011). The catch (in weight) is dominated by recruits and juveniles (ages 0–3).
Other Abundance Indices	-
Trends in Other Relevant Indicator or Variables	Recruitment has fluctuated without trend over the assessment period (1952–2011). Recent recruitment (2005–present) is highly uncertain, making short-term forecasting difficult.
Projections and Prognosis	
Stock Projections or Prognosis	Results of the future stock projection suggest that in the short-term (2009–2010) and under recent levels of F, SB will decline.
Probability of Current Catch or TACC causing Biomass to remain below or to decline below Limits	Soft Limit: Very Likely (> 90%) Hard Limit: Very Likely (> 90%)

Probability of Current Catch or TACC causing Overfishing to continue or to commence	Very Likely (> 90%)

Assessment Methodology and Evaluation		
Assessment Type	Level 1: Quantitative Stock assessment	
Assessment Method	Quantitative assessment in Stock Synthesis	
Assessment Dates	Latest assessment: 2014	Next assessment: Unknown
Overall assessment quality rank	1 – High Quality	
Main data inputs (rank)	- catch - size composition - catch-per-unit of effort (CPUE) from 1952 to 2011	1 – High Quality 1 – High Quality 2 – Medium Quality
Data not used (rank)	N/A	
Changes to Model Structure and Assumptions	-	
Major Sources of Uncertainty	- Steepness (fixed at 0.99) - The assumed natural mortality rate	

Qualifying Comments
-

Fishery Interactions
Interactions with protected species are known to occur in the longline fisheries of the South Pacific, particularly south of 25°S. Seabird bycatch mitigation measures are required in the New Zealand and Australian EEZs and through the WCPFC Conservation and Management Measure CMM2007-04. Sea turtles also get incidentally captured in longline gear; the WCPFC is attempting to reduce sea turtle interactions through Conservation and Management Measure CMM2008-03. Shark bycatch is common in longline fisheries and largely unavoidable; this is being managed through New Zealand domestic legislation and to a limited extent through Conservation and Management Measure CMM2010-07.

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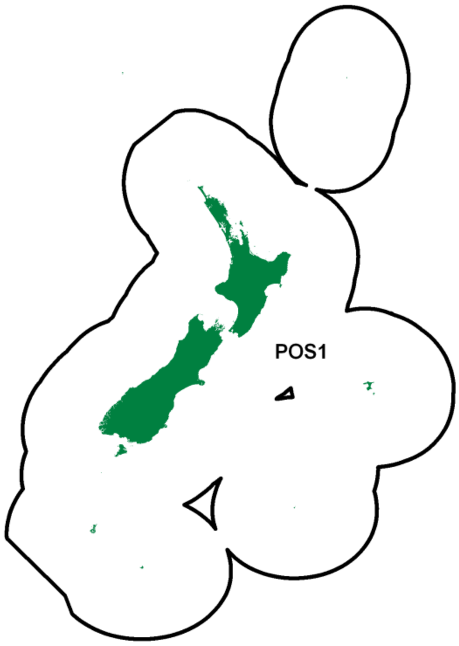
PORBEAGLE SHARK (POS)

(*Lamna nasus)*



1. FISHERY SUMMARY

Porbeagle shark were introduced into the QMS on 1 October 2004 under a single QMA, POS 1, with a TAC of 249 t, a TACC of 215 t and a recreational allowance of 10 t. The TAC was reviewed in 2012 with the reduced allocation and allowances applied from 1 October 2012 in Table 1. The decrease was in response to sustainability concerns surrounding porbeagle sharks which are slow growing and have low fecundity, making them particularly vulnerable to overexploitation.

Table 1: Recreational and Customary non-commercial allowances, TACCs and TACs (all in tonnes) for porbeagle shark.

Fishstock	Recreational Allowance	Customary non-commercial Allowance	Other mortality	TACC	TAC
POS 1	6	2	11	110	129

Porbeagle shark was added to the Third Schedule of the 1996 Fisheries Act with a TAC set under s14 because porbeagle shark is a highly migratory species and it is not possible to estimate MSY for the part of the stock that is found within New Zealand fisheries waters.

Porbeagle shark was also added to the Sixth Schedule of the 1996 Fisheries Act with the provision that:

> "A commercial fisher may return any porbeagle shark to the waters from which it was taken from if –
> (a) that porbeagle shark is likely to survive on return; and
> (b) the return takes place as soon as practicable after the porbeagle shark is taken."

Management of the porbeagle shark throughout the western and central Pacific Ocean (WCPO) is the responsibility of the Western and Central Pacific Fisheries Commission (WCPFC). Under this regional convention New Zealand is responsible for ensuring that the management measures applied within New Zealand fisheries waters are compatible with those of the Commission.

1.1 Commercial fisheries

About three-quarters of the commercial catch of porbeagle shark is taken by tuna longliners, and most of the rest by mid-water trawlers. About 60% of porbeagle sharks caught by tuna longliners are processed, and the rest are discarded. A high proportion of the catch was finned, but an increasing proportion of released sharks was reported as green, and small amounts were processed for their flesh. Figure 1 shows historical landings and longline fishing effort for POS 1.

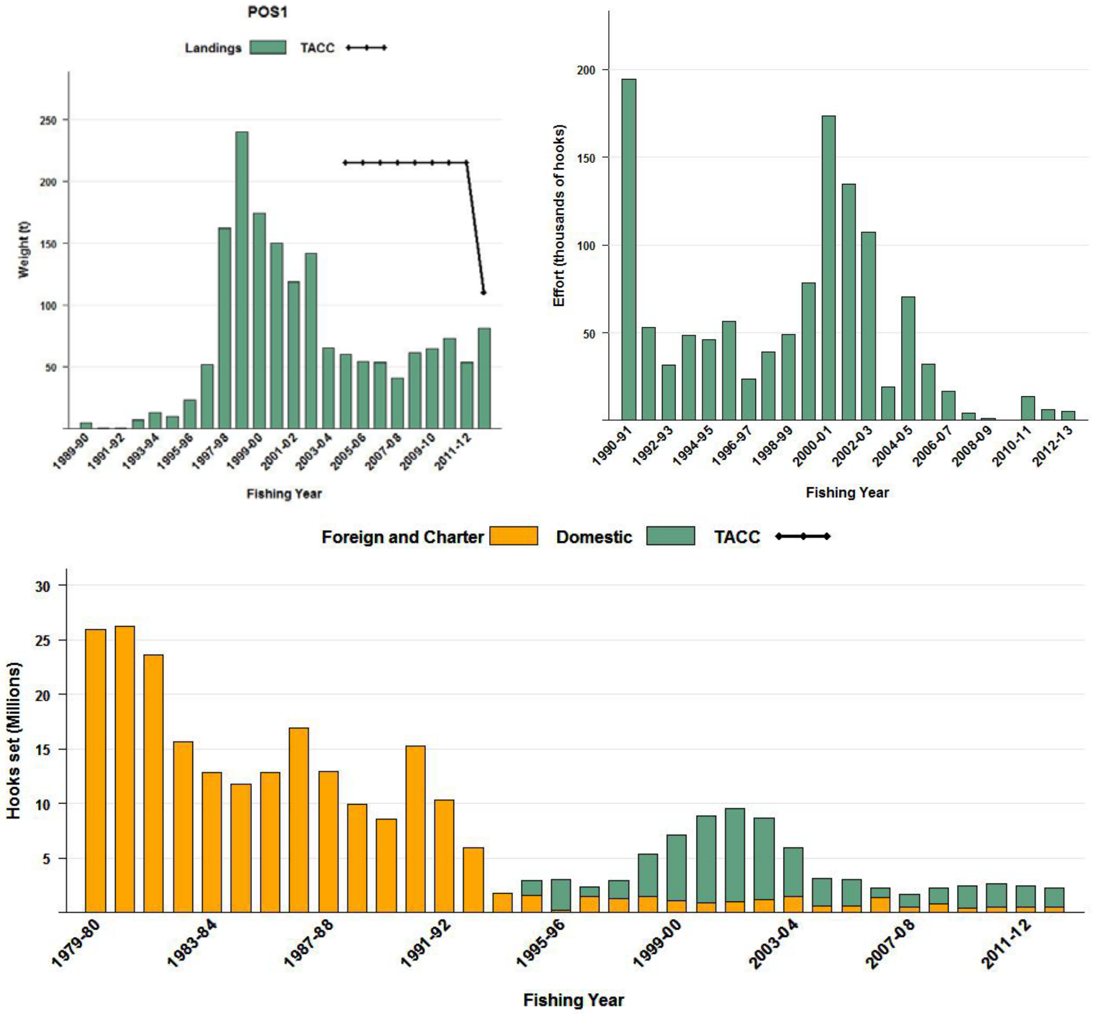


Figure 1: [Top left] Catch of porbeagle sharks from 1989–90 to 2012–13 within NZ waters (POS 1). [Top right] Fishing effort (number of hooks set) for high seas New Zealand flagged surface longline vessels from 1990–91 to 2012–13. [Bottom] Fishing effort for all domestic vessels (including effort by foreign vessels chartered by NZ fishing companies), from 1979–80 to 2012–13.

Landings of porbeagle sharks reported by fishers on CELR (landed), CLR, or TLCERs and by processors on LFRR and MHR forms are shown in Table 2. The total weights reported by fishers were 43–301 t during 1997–98 to 2008–09. Processors reported 54–240 t during1997-98 to 2012-13. There has been an 86% decline in the total weight of porbeagle shark reported since 1998–99, to a low of 41 t in 2007–08. This decline began during a period of rapidly increasing domestic fishing effort in the tuna longline fishery, but has accelerated since tuna longline effort dropped in the 2002–03 fishing year.

Catches of porbeagle sharks by tuna longliners are concentrated off the west and southwest coast of the South Island, and the northeast coast of North Island. The target species for this fishery are mainly southern bluefin, bigeye and albacore tuna. Most of the porbeagle landings reported on TLCER forms were taken in FMAs 1, 2 & 7, with significant amounts also coming from trawl fisheries in FMAs 3, 5 and 6.

Table 2: New Zealand commercial landings (t) of porbeagle sharks reported by fishers on CELRs, CLRs, or TLCERs) and processors (LFRRs or MHRs) by fishing year. (– no data available).

Year	Total reported	LFRR/MHR
1989–90	–	5
1990–91	1	1
1991–92	1	1
1992–93	7	7
1993–94	10	13
1994–95	16	10
1995–96	26	23
1996–97	39	52
1997–98	205	162
1998–99	301	240
1999–00	215	174
2000–01	188	150
2001–02	161	119
2002–03*	152	142
2003–04*	84	65
2004–05*	62	60
2005–06*	54	55
2006–07*	53	54
2007–08*	43	41
2008–09*	64	61
2009–10*	–	65
2010–11*	–	73
2011–12*	–	54
2012–13*	–	81

*MHR rather than LFRR data.

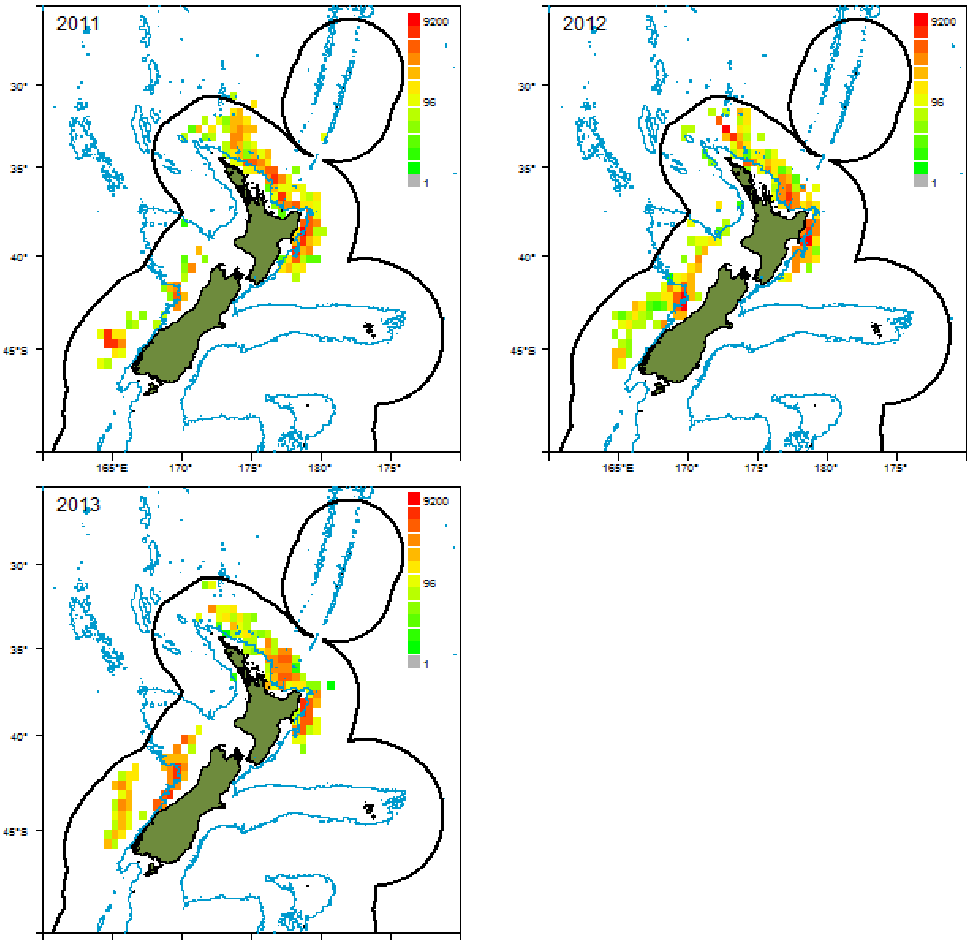


Figure 2: Porbeagle shark catches (kg) by the surface longline fishery in 0.5 degree rectangles by fishing year. Note the log scale used for the colour palette. Depth contour = 1000 m.

The majority of porbeagle shark are caught in the southern bluefin tuna target surface longline fishery (34%), followed by bigeye tuna (19%) and a small proportion (11%) are landed in the hoki target mid-water trawl fishery (Figure 3). Across all surface longline fisheries albacore make up the bulk of the catch (33%) (Figure 4). Longline fishing effort is distributed along the east coast of the North Island and the south west coast of the South Island. The west coast South Island fishery predominantly targets southern bluefin tuna, whereas the east coast of the North Island targets a range of species including bigeye, swordfish, and southern bluefin tuna (Figure 5).

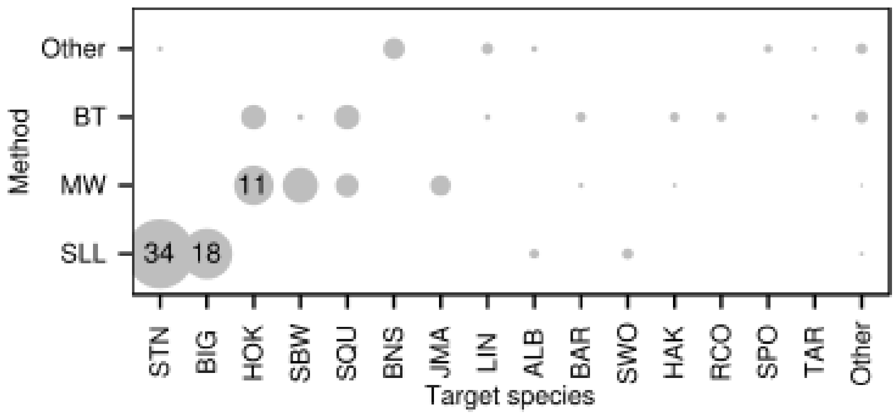


Figure 3: A summary of the proportion of landings of porbeagle shark taken by each target fishery and fishing method. The area of each circle is proportional to the percentage of landings taken using each combination of fishing method and target species. The number in the circle is the percentage (Bentley et al 2013).

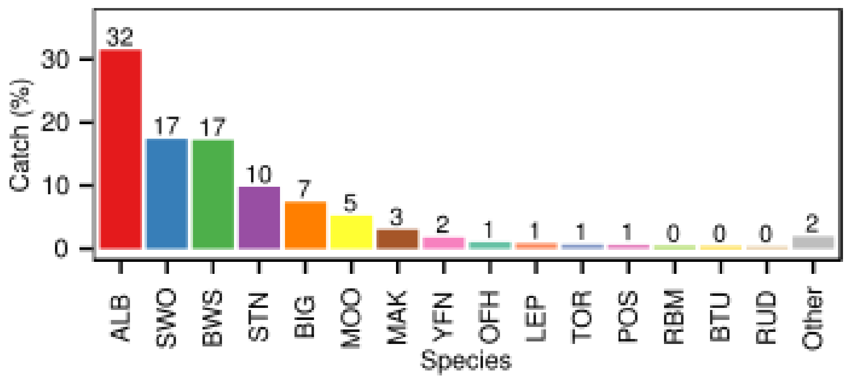


Figure 4: A summary of species composition of the reported surface longline fishery catch. The percentage by weight of each species is calculated for all trips classified under the activity (Bentley et al 2013).

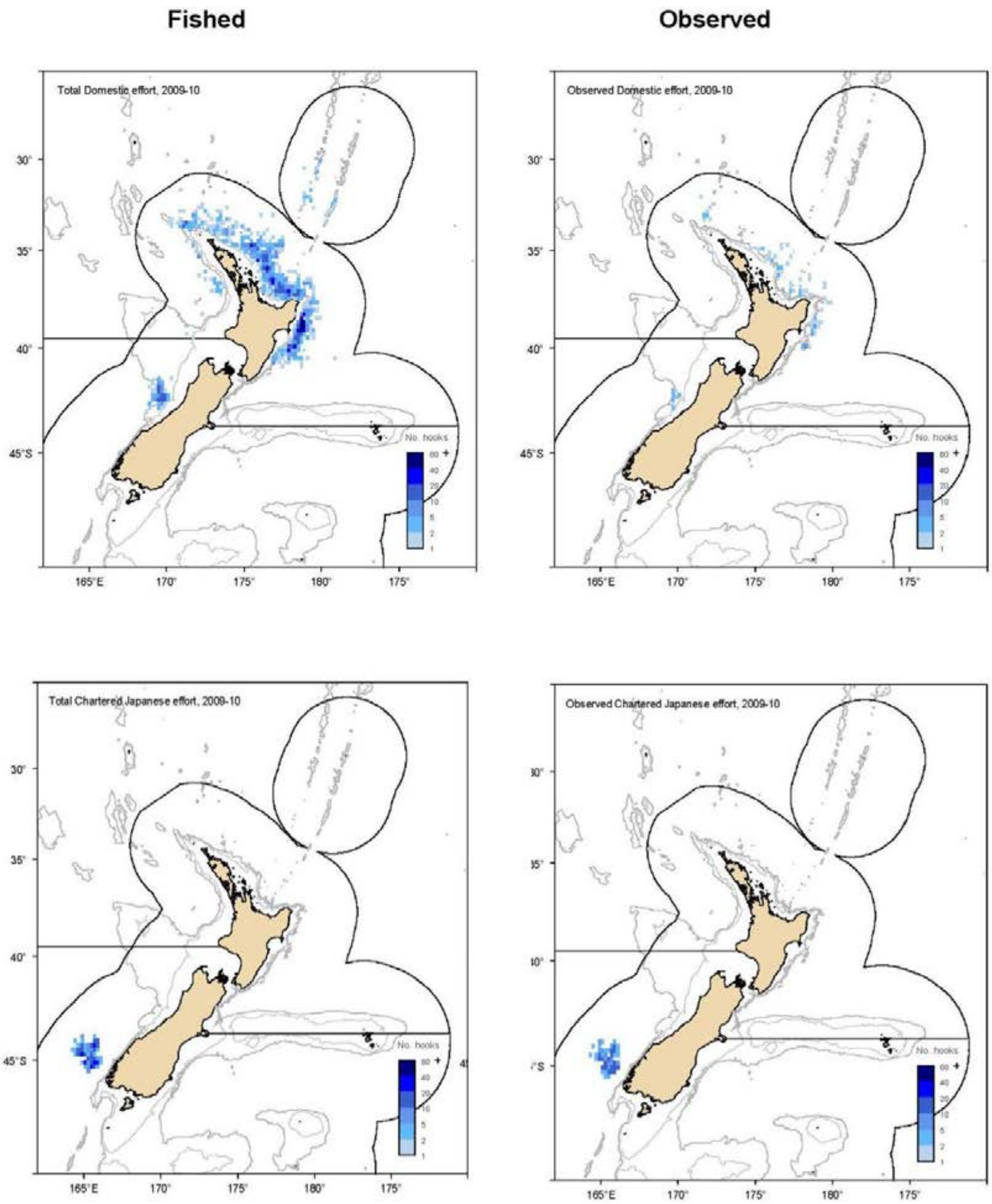


Figure 5: Distribution of fishing positions for domestic (top two panels) and charter (bottom two panels) vessels, for the 2009–10 fishing year, displaying both fishing effort (left) and observer effort (right).

Across all fleets in the longline fishery, 64.2% of the porbeagle sharks were alive when brought to the side of the vessel (Table 3). The domestic fleets retain around 35–47% of their porbeagle shark catch, mostly for the fins, while the foreign charter fleet retain most of the porbeagle sharks (79–92%) (mostly for fins; Table 4).

Table 3: Percentage of porbeagle shark (including discards) that were alive or dead when arriving at the longline vessel and observed during 2006–07 to 2009–10, by fishing year, fleet and region. Small sample sizes (number observed < 20) were omitted (Griggs & Baird 2013).

Year	Fleet	Area	% alive	% dead	Number
2006–07	Charter	North	60.5	39.5	223
		South	87.3	12.7	370
	Domestic	North	44.8	55.2	134
	Total		**71.3**	**28.7**	**727**
2007–08	Charter	South	77.6	22.4	49
	Domestic	North	59.6	40.4	488
	Total		**61.3**	**38.7**	**537**
2008–09	Charter	North	91.0	9.0	78
		South	85.4	14.6	158
	Domestic	North	57.9	42.1	254
	Total		**71.5**	**28.5**	**494**
2009–10	Charter	South	82.4	17.6	68
	Domestic	North	40.4	59.6	322
		South	30.0	70.0	20
	Total		**46.8**	**53.2**	**410**
Total all strata			**64.2**	**35.8**	**2 168**

Table 4: Percentage of porbeagle shark that were retained, or discarded or lost, when observed on a longline vessel during 2006–07 to 2009–10, by fishing year and fleet. Small sample sizes (number observed < 20) omitted (Griggs & Baird 2013).

Year	Fleet	% retained or finned	% discarded or lost	Number
2006–07	Charter	86.6	13.4	628
	Domestic	38.1	61.9	134
	Total	**78.1**	**21.9**	**762**
2007–08	Charter	89.8	10.2	49
	Domestic	35.7	64.3	488
	Total	**40.6**	**59.4**	**537**
2008–09	Charter	91.1	8.9	257
	Domestic	46.9	53.1	258
	Total	**68.9**	**31.1**	**515**
2009–10	Charter	79.2	20.8	72
	Domestic	46.0	54.0	348
	Total	**51.7**	**48.3**	**420**
Total all strata		**62.0**	**38.0**	**2 234**

1.2 Recreational fisheries

An estimate of the recreational harvest is not available. The recreational catch of porbeagle sharks is probably negligible, because they usually occur over the outer continental shelf or beyond. They are occasionally caught by gamefishers but most are tagged and released. In 2001, 40 porbeagle sharks were tagged by recreational fishers but numbers have dwindled from this peak to one or two per year.

1.3 Customary non-commercial fisheries

An estimate of the current customary catch is not available. The Maori customary catch of porbeagle sharks is probably negligible, because they usually occur over the outer continental shelf or beyond.

1.4 Illegal catch

There is no known illegal catch of porbeagle sharks.

1.5 Other sources of mortality

Many of the porbeagle sharks caught by tuna longliners (about 64%) are alive when the vessel retrieves the line, but it is not known how many of the released, discarded sharks survive.

2. BIOLOGY

Porbeagles live mainly in the latitudinal bands 30–50°S and 30–70°N. They occur in the North Atlantic Ocean, and in a circumglobal band in the Southern Hemisphere. Porbeagles are absent from the North Pacific Ocean, where the closely related salmon shark, *Lamna ditropis*, fills their niche. In the South Pacific Ocean, porbeagles are caught north of 30°S in winter–spring only; in summer they are not found north of about 35°S. They appear to penetrate further south during summer and autumn, and are found near many of the sub-Antarctic islands in the Indian and South-west Pacific Oceans. Porbeagle sharks are not found in the equatorial tropics.

Porbeagles are live-bearers (aplacental viviparous), and the length at birth is 58–67 cm fork length (FL) in the South-west Pacific. Females mature at around 170–180 cm FL and males at about 140–150 cm FL. The gestation period is about 8–9 months. In the North-west Atlantic, all females sampled in winter were pregnant, suggesting that there is no extended resting period between pregnancies, and that the female reproductive cycle lasts for one year. Litter size is usually four embryos, with a mean litter size in the South-west Pacific of 3.75. If the reproductive cycle lasts one year, annual fecundity would be about 3.75 pups per female.

A study of the age and growth of New Zealand porbeagles produced growth curves and estimates of the natural mortality rate (Table 5). However, attempts to validate ages using bomb radiocarbon analysis were unsuccessful, but suggested that the ages of porbeagles older than about 20 years were progressively under-estimated; for the oldest sharks the age under-estimation may have been as much as 50%. Consequently, the growth parameters provided in Table 5 are probably only accurate for ages up to about 20 years. Males mature at 8–11 years, and females mature at 15–18 years. Longevity is unknown but may be about 65 years.

In New Zealand, porbeagle sharks recruit to commercial fisheries during their first year at about 70 cm FL, and much of the commercial catch is immature. Most sharks caught by tuna longliners are 70–170 cm FL. The size and sex distribution of both sexes is similar up to about 150 cm, but larger individuals are predominantly male; few mature females are caught. Regional differences in length composition suggest segregation by size. The size and sex composition of sharks caught by trawlers are unknown.

Porbeagles are active pelagic predators of fish and cephalopods. Pelagic fish dominate the diet but squid are also commonly eaten, especially by the small sharks.

Table 5: Estimates of biological parameters.

Fishstock	Estimate			Source
1. Natural mortality (M)				
POS 1	0.05–0.10			Francis (unpub. data)
2. Weight = a (length)^b (Weight in kg, length in cm fork length)				
		a	*b*	
POS 1, both sexes		2.143×10^{-5}	2.924	Ayers et al (2004)
3. Von Bertalanffy model parameter estimates				
	k	t_0	L_∞	
POS 1 males	0.112	-4.75	182.2	Francis et al (2007)
POS 1 females	0.060	-6.86	233.0	Francis et al (2007)

3. STOCKS AND AREAS

In the North-west Atlantic, most tagged sharks moved short to moderate distances (up to 1500 km) along continental shelves, although one moved about 1800 km off the shelf into the mid-Atlantic Ocean. Sharks tagged off southern England were mainly recaptured between Denmark and France, with one shark moving 2370 km to northern Norway. Only one tagged shark has crossed the Atlantic: it travelled 4260 km from South-west Eire to 52°W off eastern Canada. Thus porbeagles from the northwest and northeast Atlantic appear to form two distinct stocks. There have been no genetic studies to determine the number of porbeagle stocks, but based on the disjunct (antitropical) geographical distribution and differences in biological parameters, North Atlantic porbeagles are probably reproductively isolated from Southern Hemisphere porbeagles.

The stock structure of porbeagle sharks in the Southern Hemisphere is unknown. However, given the scale of movements of tagged sharks, it seems likely that sharks in the South-west Pacific comprise a single stock. There is no evidence to indicate whether this stock extends to the eastern South Pacific or Indian Ocean.

4. ENVIRONMENTAL AND ECOSYSTEM CONSIDERATIONS

This section was updated for the November 2014 Fishery Assessment Plenary after review by the Aquatic Environment Working Group. This summary is from the perspective of the porbeagle shark but there is no directed fishery for them and the incidental catch sections below reflect the New Zealand longline fishery as a whole and are not specific to this species; a more detailed summary from an issue-by-issue perspective is available in the Aquatic Environment and Biodiversity Annual Review where the consequences are also discussed (http://www.mpi.govt.nz/Default.aspx?TabId=126&id=2122) (Ministry for Primary Industries 2013a).

4.1 Role in the ecosystem

4.1.1 Diet

Porbeagle shark (*Lamna nasus*) are active pelagic predators of fish and cephalopods. Porbeagle sharks less than 75 cm feed mostly on squid but their diet changes to fish as they grow, with fish comprising more than 60% of the diet for porbeagle sharks 75 cm and over (Figure 6) (Griggs et al 2007).

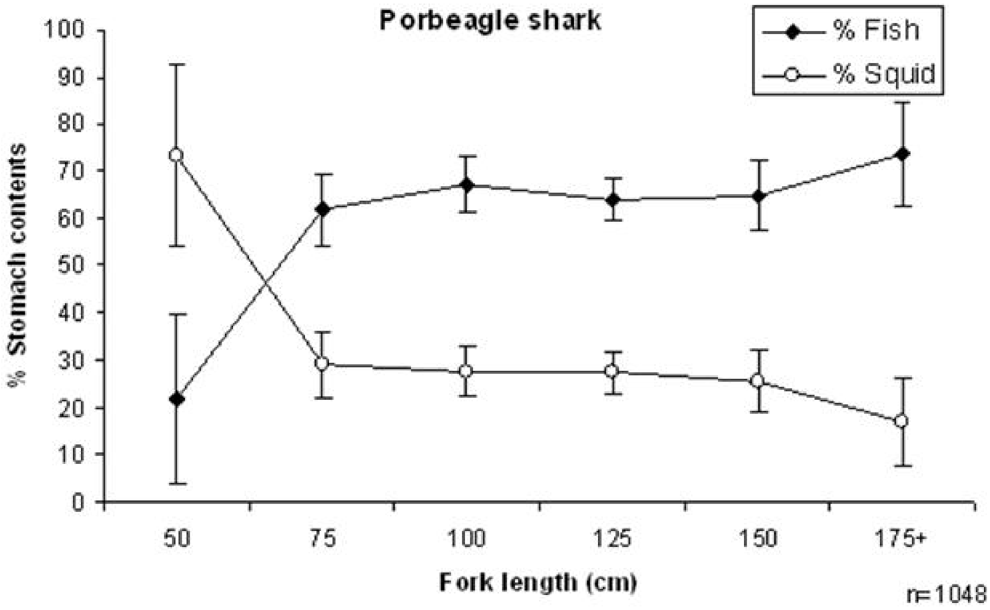


Figure 6: Changes in percentage of fish and squid in stomachs of porbeagle sharks as a function of fork length.

4.2 Incidental catch (seabirds, sea turtles and mammals)

The protected species, capture estimates presented here include all animals recovered onto the deck (alive, injured or dead) of fishing vessels but do not include any cryptic mortality (e.g., seabirds caught on a hook but not brought onboard the vessel).

4.2.1 Seabird bycatch

Between 2002–03 and 2012–13, there were 818 observed captures of birds across other surface longline target fisheries (those not targeting albacore tuna, bigeye tuna, southern bluefin tuna, pacific bluefin tuna and swordfish). Seabird capture rates since 2003 are presented in Table 6 and Figures 7 and 8. Seabird captures were more frequent off the south west coast of the South Island (Figure 9). Bayesian models of varying complexity dependent on data quality have been used to estimate captures across a range of methods (Richard & Abraham 2014). Observed and estimated seabird captures in albacore longline fisheries are provided in Table 7.

Through the 1990s the minimum seabird mitigation requirement for surface longline vessels was the use of a bird scaring device (tori line) but common practice was that vessels set surface longlines primarily at night. In 2007 a notice was implemented under s 11 of the Fisheries Act 1996 to formalise the requirement that surface longline vessels only set during the hours of darkness and use a tori line when setting. This notice was amended in 2008 to add the option of line weighting and tori line use if setting during the day. In 2011 the notices were combined and repromulgated under a new regulation (Regulation 58A of the Fisheries (Commercial Fishing) Regulations 2001) which provides a more flexible regulatory environment under which to set seabird mitigation requirements.

Risk posed by commercial fishing to seabirds has been assessed via a level 2 method which supports much of the NPOA-Seabirds 2013 risk assessment framework (MPI 2013b). The method used in the level 2 risk assessment arose initially from an expert workshop hosted by the Ministry of Fisheries in 2008. The overall framework is described in Sharp et al. (2011) and has been variously applied and improved in multiple iterations (Waugh et al. 2009, Richard et al. 2011, Richard and Abraham 2013, Richard et al. 2013 and Richard & Abraham in press). The method applies an "exposure-effects" approach where exposure refers to the number of fatalities is calculated from the overlap of seabirds with fishing effort compared with observed captures to estimate the species vulnerability (capture rates per encounter) to each fishery group. This is then compared to the population's productivity, based on population estimates and biological characteristics to yield estimates of population-level risk.

The 2014 iteration of the seabird risk assessment (Richard & Abraham in press) assessed other surface longline target fisheries (those not targeting albacore tuna, bigeye tuna, southern bluefin tuna, pacific bluefin tuna and swordfish) contribution to the total risk posed by New Zealand commercial fishing to seabirds (see Table 8). These target fisheries contribute 0.003 of PBR_1 to the risk to Southern Buller's albatross which was assessed to be at very high risk from New Zealand commercial fishing (Richard & Abraham in press).

Table 6: Number of observed seabird captures in the New Zealand surface longline fisheries, 2002–03 to 2012–13, by species and area. See glossary above for a description of the areas used for summarising the fishing effort and protected species captures. The risk ratio is an estimate of aggregate potential fatalities across trawl and longline fisheries relative to the Potential Biological Removals, PBR (from Richard and Abraham (2013) where full details of the risk assessment approach can be found). It is not an estimate of the risk posed by fishing for porbeagle shark using longline gear but rather the total risk for each seabird species. Other data, version 20130305.

Albatross Species	Risk Ratio	Kermadec Islands	Northland and Hauraki	Bay of Plenty	East Coast North Island	Stewart Snares Shelf	Fiordland	West Coast South Island	West Coast North Island	Total
Salvin's	Very high	0	1	2	6	0	0	0	0	9
Southern Buller's	Very high	0	5	2	27	0	280	39	0	353
NZ white-capped	Very high	0	2	0	3	10	62	36	1	114
Northern Buller's	High	0	0	0	1	0	0	0	0	1
Gibson's	High	4	16	0	17	0	6	3	1	47
Antipodean	High	12	10	1	8	0	0	0	1	32
Northern royal	Medium	0	0	1	0	0	0	0	0	1
Southern royal	Medium	0	1	0	0	0	4	1	0	6
Campbell black-browed	Medium	2	10	2	29	0	3	3	1	50
Light-mantled sooty	Very low	0	0	0	0	0	0	1	0	1
Unidentified	N/A	38	2	0	2	0	0	0	1	43
Total	**N/A**	**56**	**47**	**8**	**93**	**10**	**355**	**83**	**5**	**657**

Other seabirds

	Risk Ratio	Kermadec Islands	Northland and Hauraki	Bay of Plenty	East Coast North Island	Stewart Snares Shelf	Fiordland	West Coast South Island	West Coast North Island	Total
Black petrel	Very high	1	10	1	0	0	0	0	1	13
Flesh-footed shearwater	Very high	0	0	0	10	0	0	0	2	12
Cape petrel	High	0	0	0	2	0	0	0	0	2
Westland petrel	Medium	0	0	0	2	0	1	6	0	9
White-chinned petrel	Medium	2	3	3	3	1	20	3	3	38
Grey petrel	Medium	3	4	3	38	0	0	0	0	48
Grey-faced petrel	Very low	12	5	1	2	0	0	0	0	20
Sooty shearwater	Very low	1	0	0	8	3	1	0	0	13
Southern giant petrel	-	0	0	2	0	0	0	0	2	0
White-headed petrel	-	2	0	0	0	0	0	0	0	2
Unidentified	N/A	0	1	0	0	0	1	0	0	2
Total	**N/A**	**21**	**23**	**10**	**65**	**4**	**23**	**9**	**8**	**159**

Table 7: Effort, observed and estimated seabird captures by fishing year for the New Zealand surface longline fishery within the EEZ. For each fishing year, the table gives the total number of hooks; the number of observed hooks; observer coverage (the percentage of hooks that were observed); the number of observed captures; the capture rate (captures per thousand hooks); and the mean number of estimated total captures (with 95% confidence interval). Estimates are based on methods described in Estimates from 2002–03 to 2010–11 and preliminary estimates for 2012–13 are based on data version 20140131.

	Fishing effort			Observed captures		Estimated captures	
Fishing year	All hooks	Observed hooks	% observed	Number	Rate	Mean	95% c.i.
2002–2003	10 772 188	2 195 152	20.4	115	0.052	2 088	1 613–2 807
2003–2004	7 386 329	1 607 304	21.8	71	0.044	1 395	1 086–1 851
2004–2005	3 679 765	783 812	21.3	41	0.052	617	483–793
2005–2006	3 690 119	705 945	19.1	37	0.052	808	611–1 132
2006–2007	3 739 912	1 040 948	27.8	187	0.18	958	736–1 345
2007–2008	2 246 189	421 900	18.8	37	0.088	524	417–676
2008–2009	3 115 633	937 496	30.1	57	0.061	609	493–766
2009–2010	2 995 264	665 883	22.2	135	0.203	939	749–1 216
2010–2011	3 187 879	674 572	21.2	47	0.07	705	532–964
2011–2012	3 100 277	728 190	23.5	64	0.088	829	617–1 161
2012–2013†	2 862 182	560 333	19.6	27	0.048	783	567–1 144

†Provisional data, model estimates not finalised.

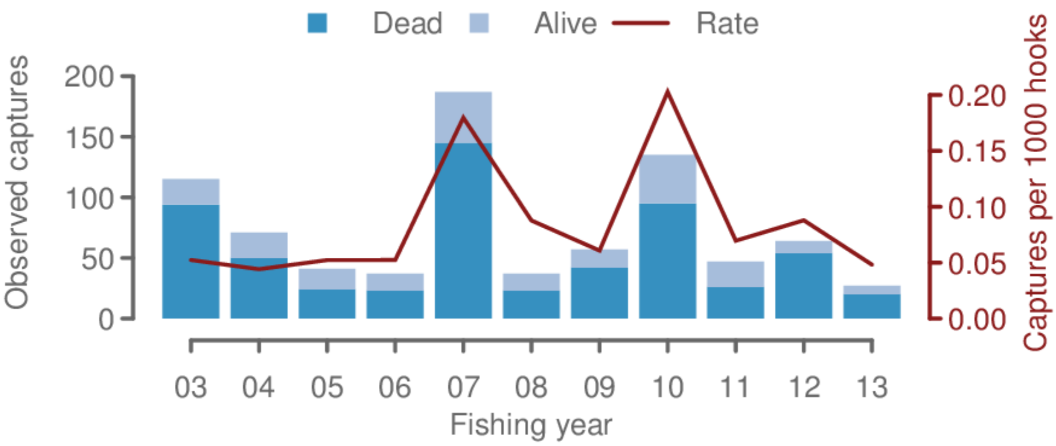


Figure 7: Observed captures of seabirds in the New Zealand surface longline fisheries from 2002–03 to 2012–13.

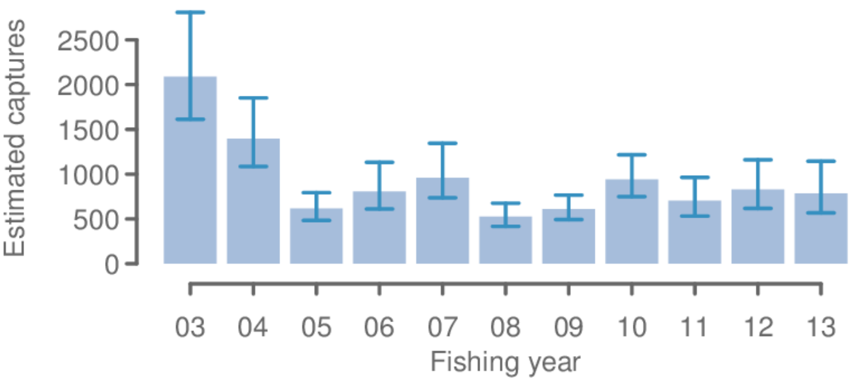


Figure 8: Estimated captures of seabirds in the New Zealand surface longline fisheries from 2002–03 to 2012–13.

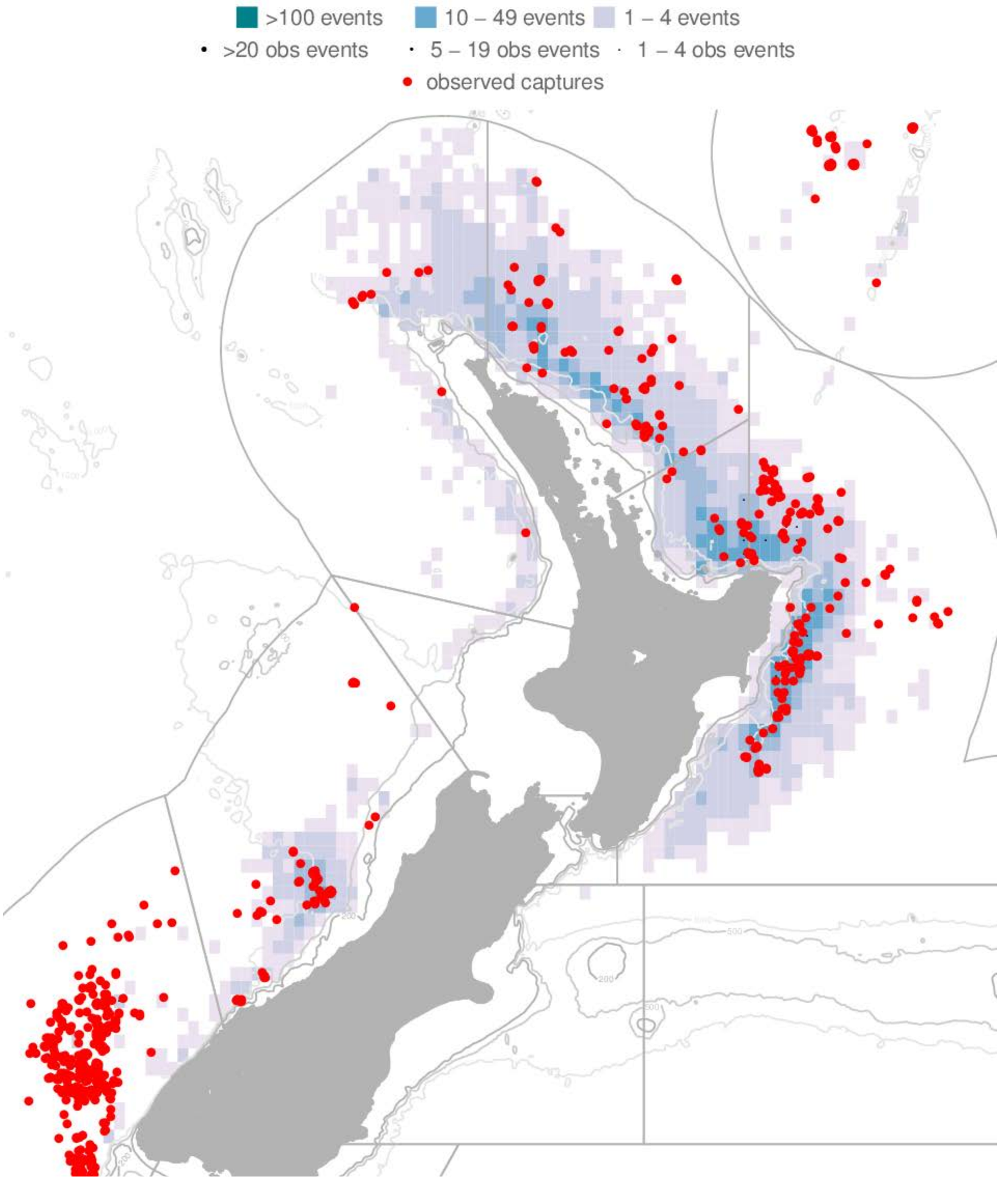


Figure 9: Distribution of fishing effort in the New Zealand surface longline fisheries and observed seabird captures, 2002–03 to 2012–13. Fishing effort is mapped into 0.2-degree cells, with the colour of each cell being related to the amount of effort. Observed fishing events are indicated by black dots, and observed captures are indicated by red dots. Fishing is only shown if the effort could be assigned a latitude and longitude, and if there were three or more vessels fishing within a cell. In this case, 89.4% of the effort is shown. See glossary for areas used for summarising the fishing effort and protected species captures.

Table 8: Risk ratio of seabirds predicted by the level two risk assessment for the other species target surface longline fisheries (those not targeting albacore tuna, bigeye tuna, southern bluefin tuna, pacific bluefin tuna and swordfish) and all fisheries included in the level two risk assessment, 2006–07 to 2012–13, showing seabird species with risk category of very or high, or a medium risk category and risk ratio of at least 1% of the total risk. The risk ratio is an estimate of aggregate potential fatalities across trawl and longline fisheries relative to the Potential Biological Removals, PBR_1 (from Richard and Abraham 2014 where full details of the risk assessment approach can be found). PBR_1 applies a recovery factor of 1.0. Typically a recovery factor of 0.1 to 0.5 is applied (based on the state of the population) to allow for recovery from low population sizes as quickly as possible. This should be considered when interpreting these results. The New Zealand threat classifications are shown (Robertson et al 2013 at http://www.doc.govt.nz/documents/science-and-technical/nztcs4entire.pdf)

	Risk ratio				
Species name	OTH target SLL	Total risk from NZ commercial fishing	% of total risk from NZ commercial fishing	Risk category	NZ Threat Classification
Black petrel	0.000	15.095	0.00	Very high	Threatened: Nationally Vulnerable
Salvin's albatross	0.000	3.543	0.00	Very high	Threatened: Nationally Critical
Southern Buller's albatross	0.003	2.823	0.10	Very high	At Risk: Naturally Uncommon
Flesh-footed shearwater	0.000	1.557	0.00	Very high	Threatened: Nationally Vulnerable
Gibson's albatross	0.000	1.245	0.00	Very high	Threatened: Nationally Critical
New Zealand white-capped albatross	0.000	1.096	0.01	Very high	At Risk: Declining
Chatham Island albatross	0.000	0.913	0.00	High	At Risk: Naturally Uncommon
Antipodean albatross	0.000	0.888	0.00	High	Threatened: Nationally Critical
Westland petrel	0.000	0.498	0.00	High	At Risk: Naturally Uncommon
Northern Buller's albatross	0.000	0.336	0.13	High	At Risk: Naturally Uncommon
Campbell black-browed albatross	0.000	0.304	0.00	High	At Risk: Naturally Uncommon
Stewart Island shag	0.000	0.301	0.00	High	Threatened: Nationally Vulnerable

4.2.2 Sea turtle bycatch

Between 2002–03 and 2012–13, there were 15 observed captures of sea turtles across all surface longline fisheries (Tables 9 and 10, Figure 10). Observer records documented all but one sea turtle as captured and released alive. Sea turtle capture distributions predominantly occur throughout the east coast of the North Island and Kermadec Island fisheries (Figure 11).

Table 9: Number of observed sea turtle captures in the New Zealand surface longline fisheries, 2002–03 to 2012–13, by species and area. Data from Thompson et al (2013), retrieved from http://data.dragonfly.co.nz/psc/. See glossary above for a description of the areas used for summarising the fishing effort and protected species captures.

Species	Bay of Plenty	East Coast North Island	Kermadec Islands	West Coast North Island	Total
Leatherback turtle	1	4	3	3	11
Green turtle	0	1	0	0	1
Unknown turtle	0	1	0	2	3
Total	1	6	3	5	15

Table 10: Effort and sea turtle captures in surface longline fisheries by fishing year. For each fishing year, the table gives the total number of hooks; the number of observed hooks; observer coverage (the percentage of hooks that were observed); the number of observed captures (both dead and alive); and the capture rate (captures per thousand hooks). For more information on the methods used to prepare the data see Thompson et al (2013).

	Fishing effort			Observed captures	
Fishing year	All hooks	Observed hooks	% observed	Number	Rate
2002–2003	10 772 188	2 195 152	20.4	0	0
2003–2004	7 386 329	1 607 304	21.8	1	0.001
2004–2005	3 679 765	783 812	21.3	2	0.003
2005–2006	3 690 119	705 945	19.1	1	0.001
2006–2007	3 739 912	1 040 948	27.8	2	0.002
2007–2008	2 246 189	421 900	18.8	1	0.002
2008–2009	3 115 633	937 496	30.1	2	0.002
2009–2010	2 995 264	665 883	22.2	0	0
2010–2011	3 187 879	674 572	21.2	4	0.006
2011–2012	3 100 277	728 190	23.5	0	0
2012–2013	2 862 182	560 333	19.6	2	0.004

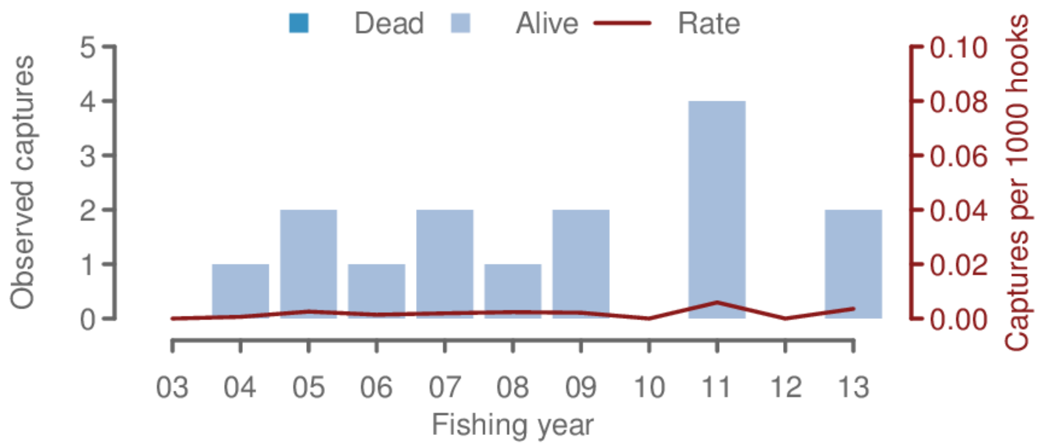


Figure 10: Observed captures of sea turtles in the New Zealand surface longline fisheries from 2002–03 to 2012–13.

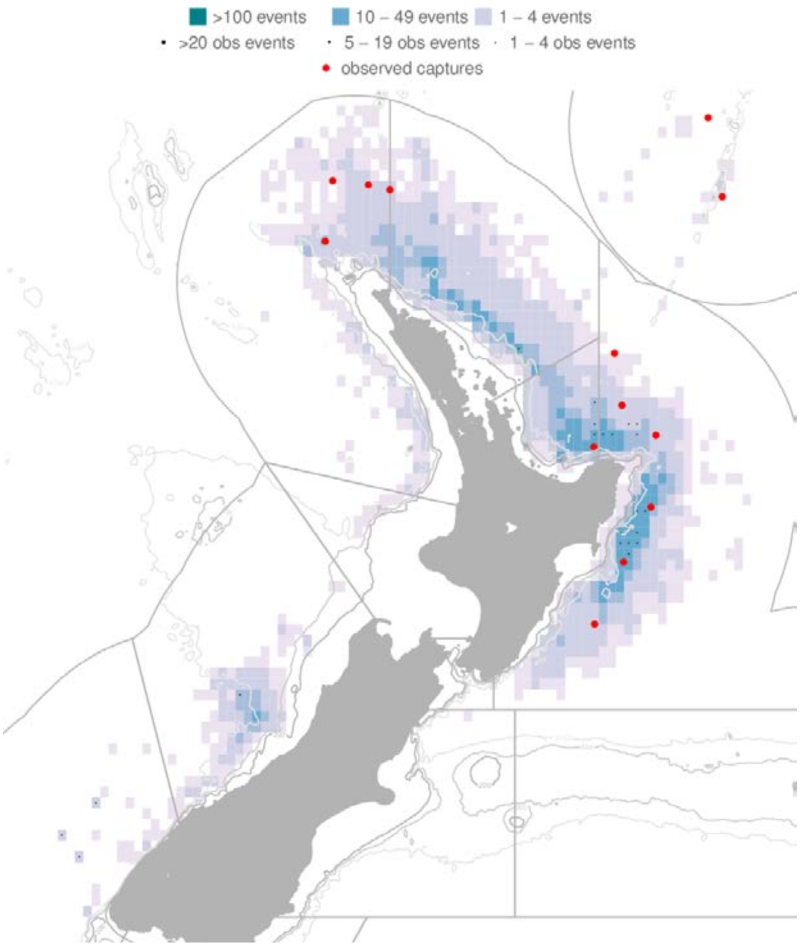


Figure 11: Distribution of fishing effort in the New Zealand surface longline fisheries and observed sea turtle captures, 2002–03 to 2012–13. Fishing effort is mapped into 0.2-degree cells, with the colour of each cell being related to the amount of effort. Observed fishing events are indicated by black dots, and observed captures are indicated by red dots. Fishing is only shown if the effort could be assigned a latitude and longitude, and if there were three or more vessels fishing within a cell. In this case, 89.4% of the effort is shown. See glossary for areas used for summarising the fishing effort and protected species captures.

4.2.3 Marine Mammals

4.2.3.1 Cetaceans

Cetaceans are dispersed throughout New Zealand waters (Perrin et al 2008). The spatial and temporal overlap of commercial fishing grounds and cetacean foraging areas has resulted in cetacean captures in fishing gear (Abraham & Thompson 2009, 2011).

Between 2002–03 and 2012–13, there were seven observed captures of whales and dolphins in surface longline fisheries. Observed captures included 5 unidentified cetaceans and 2 long-finned Pilot whales (Tables 11 and 12, Figure 12) (Thompson et al 2013). All captured animals recorded were documented as being caught and released alive (Thompson et al 2013). Cetacean capture distributions are more frequent off the east coast of the North Island (Figure 13).

Table 11: Number of observed cetacean captures in the New Zealand surface longline fisheries, 2002–03 to 2012–13, by species and area. Data from Thompson et al (2013), retrieved from http://data.dragonfly.co.nz/psc/. See glossary above for a description of the areas used for summarising the fishing effort and protected species captures.

Species	Bay of Plenty	East Coast North Island	Fiordland	Northland and Hauraki	West Coast North Island	West Coast South Island	Total
Long-finned pilot whale	0	1	0	0	0	1	2
Unidentified cetacean	1	1	1	1	1	0	5
Total	1	2	1	1	1	1	7

Table 12: Effort and captures of cetaceans in surface longline fisheries by fishing year. For each fishing year, the table gives the total number of hooks; the number of observed hooks; observer coverage (the percentage of hooks that were observed); the number of observed captures (both dead and alive); and the capture rate (captures per thousand hooks). For more information on the methods used to prepare the data, see Thompson et al (2013).

	Fishing effort			Observed captures	
Fishing year	All hooks	Observed hooks	% observed	Number	Rate
2002–2003	10 772 188	2 195 152	20.4	1	0
2003–2004	7 386 329	1 607 304	21.8	4	0.002
2004–2005	3 679 765	783 812	21.3	1	0.001
2005–2006	3 690 119	705 945	19.1	0	0
2006–2007	3 739 912	1 040 948	27.8	0	0
2007–2008	2 246 189	421 900	18.8	1	0.002
2008–2009	3 115 633	937 496	30.1	0	0
2009–2010	2 995 264	665 883	22.2	0	0
2010–2011	3 187 879	674 572	21.2	0	0
2011–2012	3 100 277	728 190	23.5	0	0
2012–2013	2 862 182	560 333	19.6	0	0

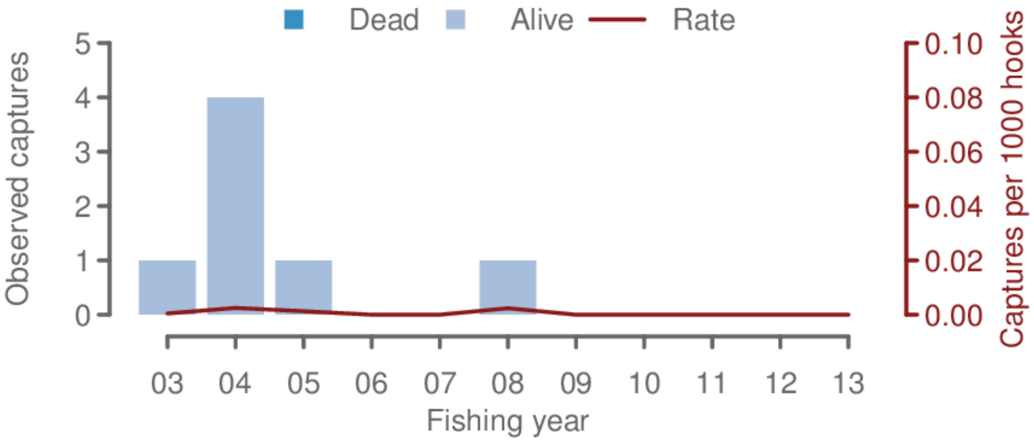


Figure 12: Observed captures of cetaceans in the New Zealand surface longline fisheries from 2002–03 to 2012–13.

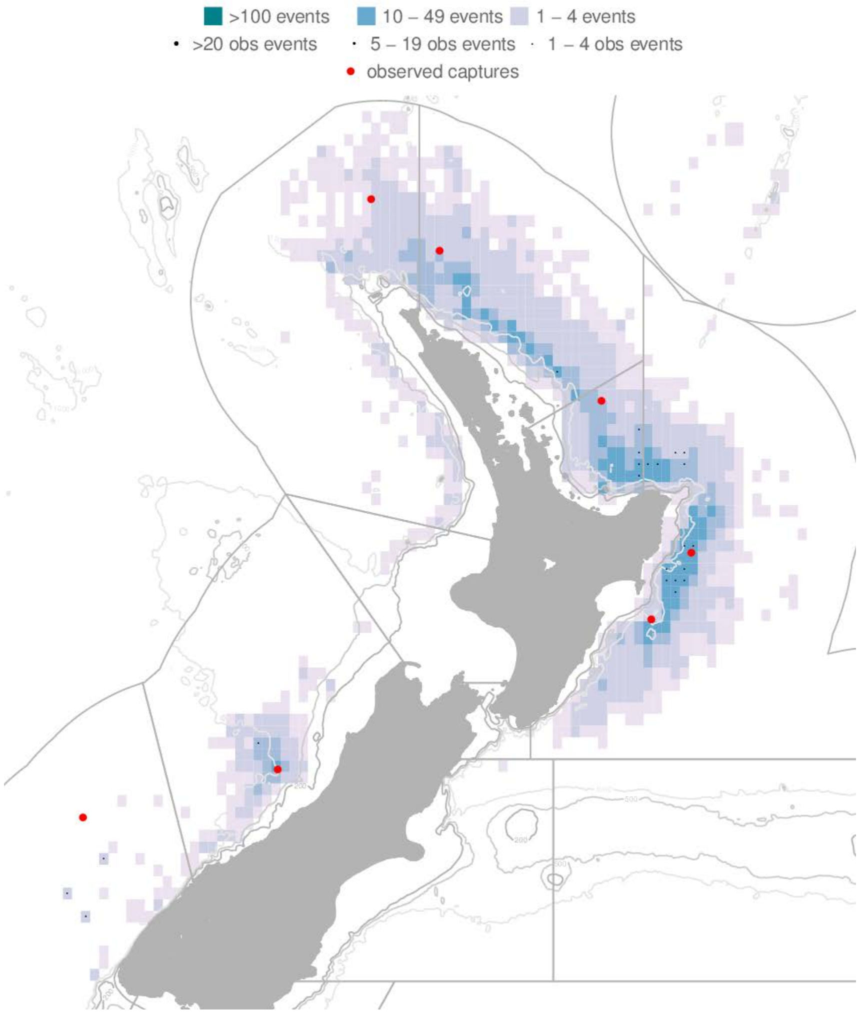


Figure 13: Distribution of fishing effort in the New Zealand surface longline fisheries and observed cetacean captures, 2002–03 to 2012–13. Fishing effort is mapped into 0.2-degree cells, with the colour of each cell being related to the amount of effort. Observed fishing events are indicated by black dots, and observed captures are indicated by red dots. Fishing is only shown if the effort could be assigned a latitude and longitude, and if there were three or more vessels fishing within a cell. In this case, 89.4% of the effort is shown. See glossary for areas used for summarising the fishing effort and protected species captures.

4.2.3.2 New Zealand fur seal bycatch

Currently, New Zealand fur seals are dispersed throughout New Zealand waters, especially in waters south of about 40º S to Macquarie Island. The spatial and temporal overlap of commercial fishing grounds and New Zealand fur seal foraging areas has resulted in New Zealand fur seal captures in fishing gear (Mattlin 1987, Rowe 2009). Most fisheries with observed captures occur in waters over or close to the continental shelf, which slopes steeply to deeper waters relatively close to shore, and thus rookeries and haulouts, around much of the South Island and offshore islands. Captures on longlines occur when the fur seals attempt to feed on the bait and fish catch during hauling. Most New Zealand fur seals are released alive, typically with a hook and short snood or trace still attached.

New Zealand fur seal captures in surface longline fisheries have been generally observed in waters south and west of Fiordland, but also in the Bay of Plenty-East Cape area when the animals have attempted to take bait or fish from the line as it is hauled. These capture rates include animals that are released alive (100% of observed surface longline capture in 2008–09; Thompson & Abraham 2010). Capture rates in 2011–12 and 2012-13 were higher than they were in the early 2000s (Figures 14 and 15). While fur seal captures have occurred throughout the range of this fishery most New Zealand captures have occurred off the Southwest coast of the South Island (Figure 16). Between 2002–03 and 2012–13, there were 267 observed captures of New Zealand fur seal in surface longline fisheries (Tables 13 and 14).

Table 13: Number of observed New Zealand fur seal captures in the New Zealand surface longline fisheries, 2002–03 to 2012–13, by species and area. Data from Thompson et al (2013), retrieved from http://data.dragonfly.co.nz/psc/. See glossary above for a description of the areas used for summarising the fishing effort and protected species captures.

	Bay of Plenty	East Coast North Island	Fiordland	Northland and Hauraki	Stewart Snares Shelf	West Coast North Island	West Coast South Island	Total
New Zealand fur seal	11	33	179	4	4	2	34	267

Table 14: Effort and captures of New Zealand fur seal in the New Zealand surface longline fisheries by fishing year. For each fishing year, the table gives the total number of hooks; the number of observed hooks; observer coverage (the percentage of hooks that were observed); the number of observed captures (both dead and alive); and the capture rate (captures per thousand hooks). Data from Thompson et al (2013), retrieved from http://data.dragonfly.co.nz/psc/. Estimates from 2002–03 to 2010–11 and preliminary estimates for 2012–13 are based on data version 20140131.

	Fishing effort			Observed captures		Estimated captures	
Fishing year	All hooks	Observed hooks	% observed	Number	Rate	Mean	95% c.i.
2002–2003	10 772 188	2 195 152	20.4	56	0.026	299	199–428
2003–2004	7 386 329	1 607 304	21.8	40	0.025	134	90–188
2004–2005	3 679 765	783 812	21.3	20	0.026	66	38–99
2005–2006	3 690 119	705 945	19.1	12	0.017	47	23–79
2006–2007	3 739 912	1 040 948	27.8	10	0.010	32	14–55
2007–2008	2 246 189	421 900	18.8	10	0.024	40	19–68
2008–2009	3 115 633	937 496	30.1	22	0.023	53	29–81
2009–2010	2 995 264	665 883	22.2	19	0.029	77	43–121
2010–2011	3 187 879	674 572	21.2	17	0.025	64	35–101
2011–2012	3 100 277	728 190	23.5	40	0.055	140	92–198
2012–2013†	2 862 182	560 333	19.6	21	0.037	110	65–171

†Provisional data, model estimates not finalised.

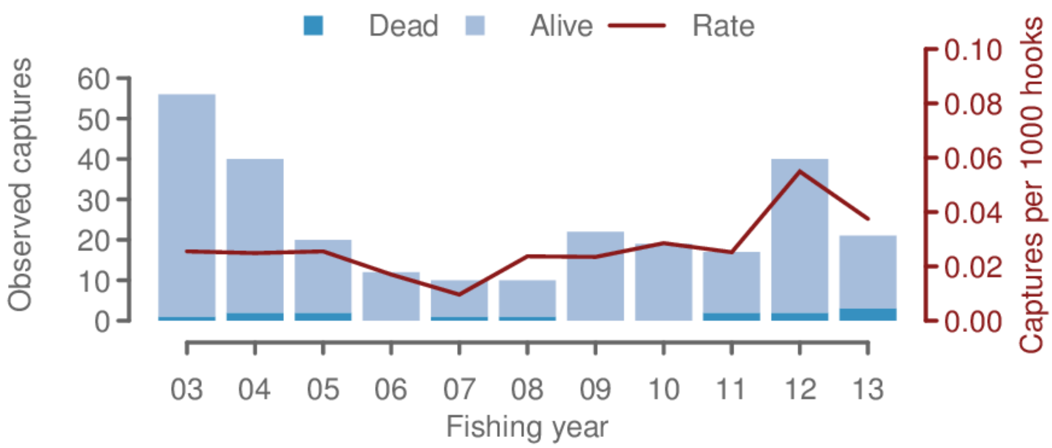


Figure 14: Observed captures of New Zealand fur seal in the New Zealand surface longline fisheries from 2002–03 to 2012–13.

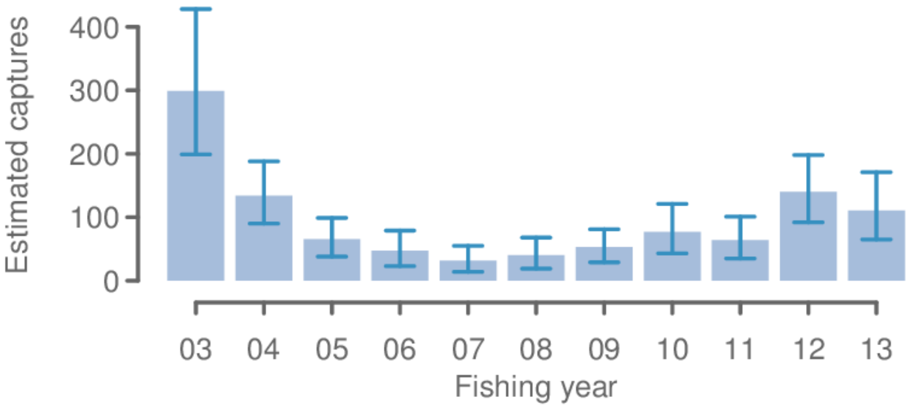


Figure 15: Estimated captures of New Zealand fur seal in the New Zealand surface longline fisheries from 2002–03 to 2012–13.

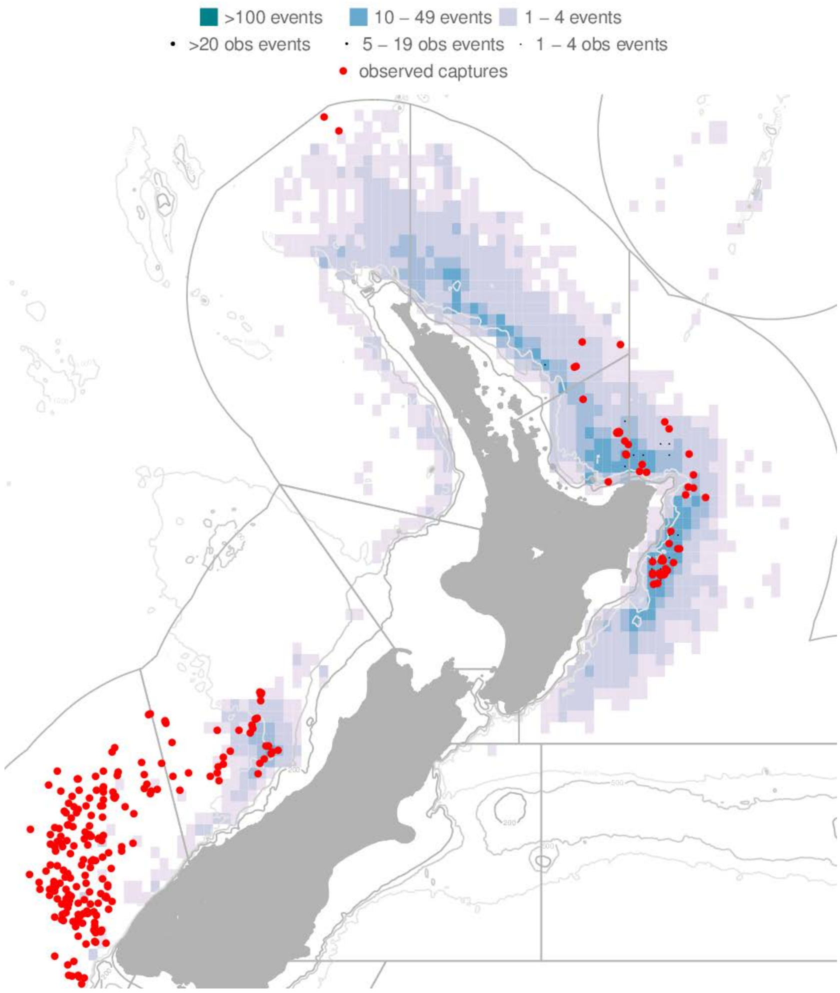


Figure 16: Distribution of fishing effort in the New Zealand surface longline fisheries and observed New Zealand fur seal captures, 2002–03 to 2012–13. Fishing effort is mapped into 0.2-degree cells, with the colour of each cell being related to the amount of effort. Observed fishing events are indicated by black dots, and observed captures are indicated by red dots. Fishing is only shown if the effort could be assigned a latitude and longitude, and if there were three or more vessels fishing within a cell. In this case, 89.4% of the effort is shown. See glossary for areas used for summarising the fishing effort and protected species captures.

4.3 Incidental fish bycatch

Observer records indicate that a wide range of species are landed by the longline fleets in New Zealand fishery waters. Blue sharks are the most commonly landed species (by number), followed by Ray's bream (Table 15). Southern bluefin tuna and albacore tuna are the only target species that occur in the top five of the frequency of occurrence.

Table 15: Total estimated catch (numbers of fish) of common bycatch species in the New Zealand longline fishery as estimated from observer data from 2009 to 2013. Also provided is the percentage of these species retained (2013 data only) and the percentage of fish that were alive when discarded, N/A (none discarded).

Species	2010	2011	2012	2013	% retained (2013)	discards % alive (2013)
Blue shark	66113	53432	132925	158736	45.2	97.4
Lancetfish	43425	37305	7866	19172	0.1	37.6
Rays bream	20041	18453	19918	13568	97.4	4.2
Porbeagle shark	4679	9929	7019	9805	34.0	79.8
Mako shark	4490	9770	3902	3981	35.5	84.9
Moonfish	5398	3418	2363	2470	99.0	0.0
Escolar	1539	6602	2181	2088	30.2	76.3
Sunfish	3148	3773	3265	1937	2.7	100.0
Pelagic stingray	1983	4090	712	1199	1.0	97.0
Butterfly tuna	1158	909	713	1030	48.1	11.1
Deepwater dogfish	377	548	647	743	1.2	88.5
Oilfish	886	1747	509	386	26.5	72.2
Rudderfish	326	338	491	362	13.0	80.0
Thresher shark	209	349	246	256	33.3	75.0
Skipjack tuna	91	255	123	240	100.0	N/A
Dealfish	1160	223	372	237	1.7	25.1
Striped marlin	471	175	124	182	0.0	44.4
Big scale pomfret	505	139	108	67	88.2	100.0
School shark	62	49	477	21	100.0	N/A

4.4 Benthic interactions

N/A

4.5 Key environmental and ecosystem information gaps

Cryptic mortality is unknown at present but developing a better understanding of this in future may be useful for reducing uncertainty of the seabird risk assessment and could be a useful input into risk assessments for other species groups.

The survival rates of released target and bycatch species is currently unknown.

Observer coverage in the New Zealand fleet is not spatially and temporally representative of the fishing effort.

5. STOCK ASSESSMENT

With the establishment of the WCPFC in 2004, future stock assessments of porbeagle shark in the western and central Pacific Ocean stock will be reviewed by the WCPFC. There is currently a shark research plan that has been developed within the context of the Western and Central Pacific Fisheries Commission but porbeagle sharks will not be a focus of that plan in the near future.

There have been no stock assessments of porbeagle sharks in New Zealand. No estimates of yield are possible with the currently available data.

Indicator analyses suggest that porbeagle shark populations in the New Zealand EEZ have not been declining under recent fishing pressure, and may have been increasing since 2005 (Figures 17and 18). These changes are presumably in response to a decline in SLL fishing effort since 2001-02 (Griggs & Baird 2013), and declines in annual landings since peaks in 1999 for porbeagle sharks (Ministry for Primary Industries 2013b). Porbeagle shark abundance may have declined rapidly in the late 1990s before stabilising at a relatively low level, or increasing as indicated by the trend in the TLCER North CPUE index. The quality of observer data and model fits means these interpretations are uncertain. The stock status of porbeagle sharks remains uncertain, but is potentially low. Conclusive determinations of stock status will require regional (i.e. South Pacific) stock assessments (Table 16).

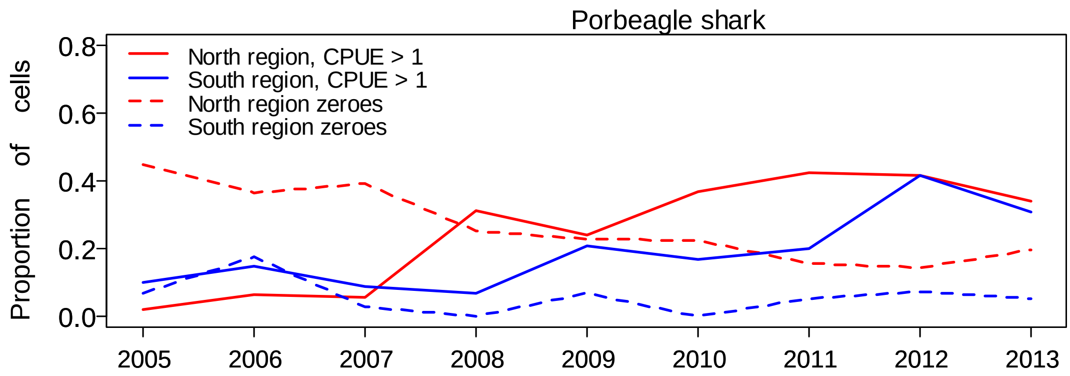


Figure 17: Porbeagle shark distribution indicators. Proportions of 0.5 degree rectangles having CPUE greater than 1 per 1000 hooks, and proportions of rectangles having zero catches, for North and South regions by fishing year, based on estimated catches (processed and discarded combined) reported on TLCERs. North region comprises Fisheries Management Areas (FMAs) 1, 2, 8, and 9, and South region comprises FMAs 5 and 7.

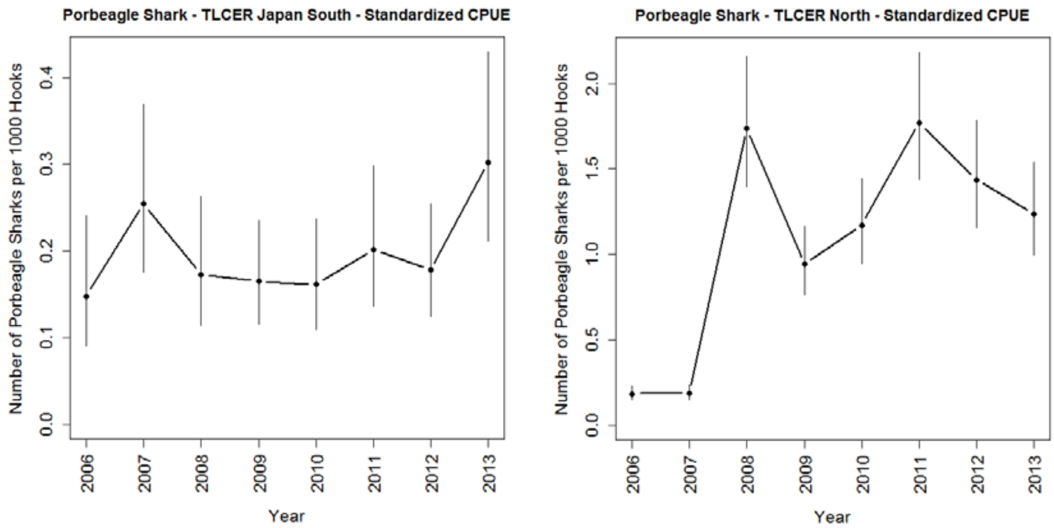


Figure 18: Standardised CPUE indices for commercial TLCER (Japan South and North) and observer datasets (all New Zealand) [Continued on next page].

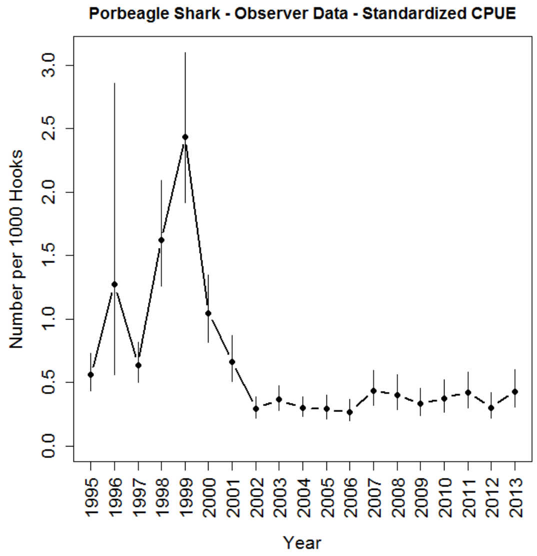


Figure 18 [Continued]: Standardised CPUE indices for commercial TLCER (Japan South and North) and observer datasets (all New Zealand).

Table 16: Summary of trends identified in abundance indicators since the 2005 fishing year based on both TLCER and observer data sets. The CPUE-Obs indicator was calculated for both North and South regions combined. North region comprises Fisheries Management Areas (FMAs) 1, 2, 8, and 9, and South region comprises FMAs 5 and 7. For the CPUE-TLCER indicator in South region, only the Japan dataset indicator is shown (the TLCER Domestic South dataset was small and probably unrepresentative). Green cells show indicators that suggest positive trends in stock size. Note that a downward trend in 'proportion-zeroes' is considered a positive stock trend. NA = indicator not applicable because of small sample size.

		North region			South region		
Indicator class	Indicator	Blue	Porbeagle	Mako	Blue	Porbeagle	Mako
Distribution	High-CPUE	Up	Up	Up	Up	Up	NA
Distribution	Proportion-zeroes	Nil	Down	Down	Nil	Nil	Down
Catch composition	GM index total catch - TLCER		Up (all species)			Up (all species)	
Catch composition	GM index total catch - Obs		Up (all species)			Nil (all species)	
Catch composition	GM index HMS shark catch - TLCER		Up (all species)			Up (all species)	
Catch composition	GM index HMS shark catch - Obs		Up (all species)			Nil (all species)	
Standardised CPUE	CPUE - TLCER	Up	Nil	Up	Up	Nil	Nil
Standardised CPUE	CPUE - Obs	Up	Nil	Nil	Up	Nil	Nil
Sex ratio	Proportion males	Nil	Nil	Nil	Nil	Nil	NA
Size composition	Median length - Males	Nil	Nil	Nil	Nil	Nil	NA
Size composition	Median length - Females	Nil	Nil	Nil	Nil	Nil	NA

Relative to a wide range of shark species, the productivity of porbeagle sharks is very low. Females have a high age-at-maturity, high longevity (and therefore low natural mortality rate) and low annual fecundity. The low fecundity is cause for strong concern, as the ability of the stock to replace sharks removed by fishing is very limited.

Observed length frequency distributions of porbeagle sharks by area and sex are shown in Figure 17 for fish measured between 1993 and 2012. Few mature females are caught by the surface longline fishery, and they are mainly taken around South Island. Mature males are frequently caught throughout New Zealand. A strong mode of 0+ juveniles occurs at 70-85 cm in northern and southwestern New Zealand, but not of the east coast of South Island where water temperatures are significantly colder.

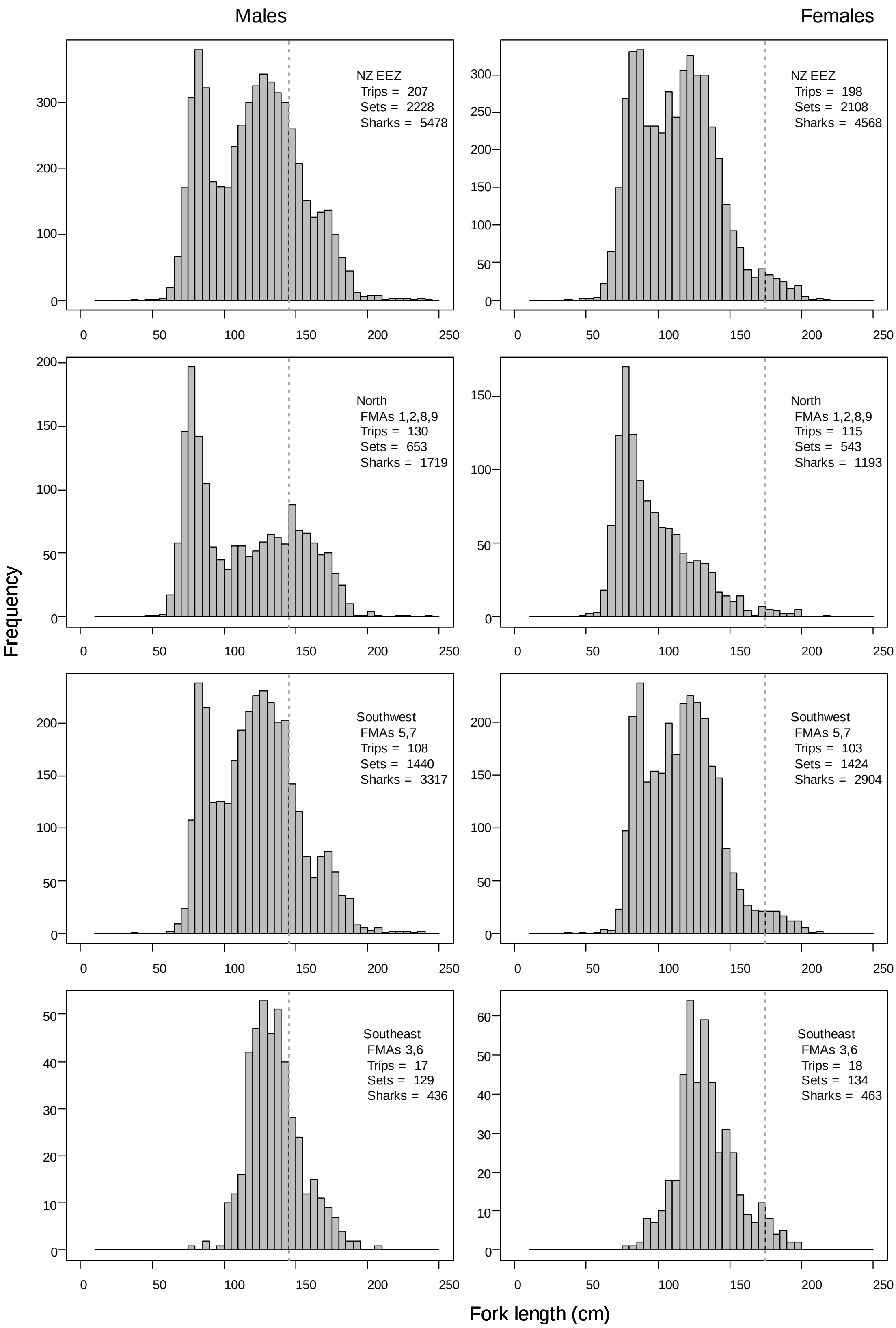


Figure 19: Length-frequency distributions of male and female porbeagle sharks measured by observers aboard surface longline vessels between 1993 and 2012 for the New Zealand EEZ, and North, Southwest and Southeast regions. The dashed vertical lines indicate the median length at maturity. Source: Francis (2013)

6. STATUS OF THE STOCK

Stock structure assumptions

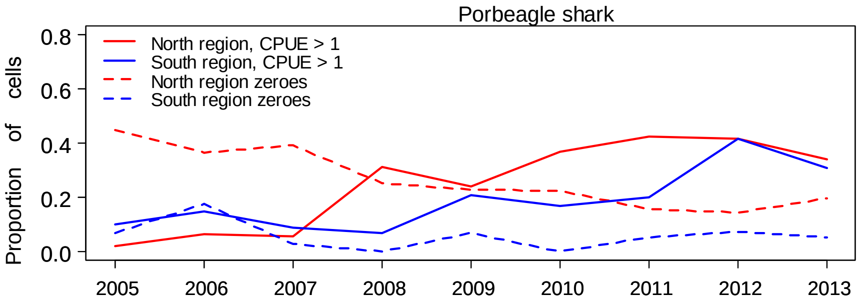
POS 1 is assumed to be part of the wider South Western Pacific Ocean stock. However, there is no stock assessment for this wider stock. The results below are from indicator analyses of the New Zealand component of that stock only.

Stock Status	
Year of Most Recent Assessment	20 14
Assessment Runs Presented	Indicator analyses only for NZ EEZ
Reference Points	Target: Not established Soft Limit: Not established but HSS default of 20% SB_0 assumed Hard Limit: Not established but HSS default of 10% SB_0 assumed Overfishing threshold: F_{MSY}
Status in relation to Target	Unknown
Status in relation to Limits	Unknown
Status in relation to Overfishing	Unknown

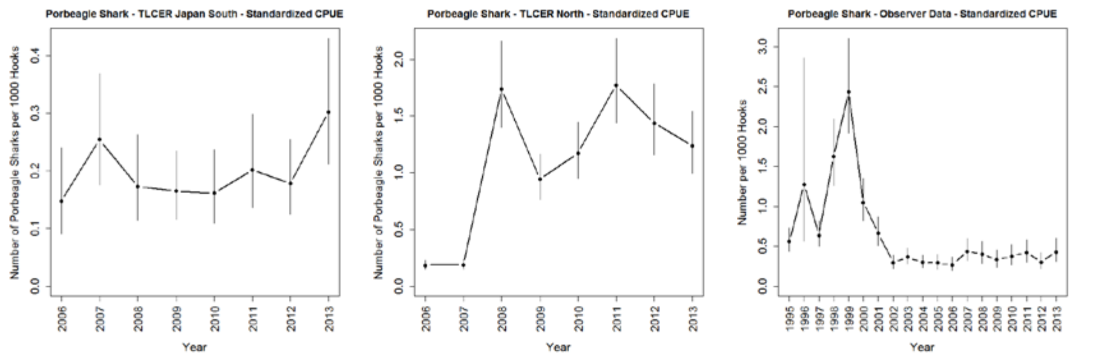
Historical Stock Status Trajectory and Current Status

Summary of trends identified in abundance indicators since the 2005 fishing year based on both TLCER and observer data sets. North region comprises Fisheries Management Areas (FMAs) 1, 2, 8, and 9, and South region comprises FMAs 5 and 7.

		North region			South region		
Indicator class	Indicator	Blue	Porbeagle	Mako	Blue	Porbeagle	Mako
Distribution	High-CPUE	Up	Up	Up	Up	Up	NA
Distribution	Proportion-zeroes	Nil	Down	Down	Nil	Nil	Down
Catch composition	GM index total catch - TLCER	Up (all species)			Up (all species)		
Catch composition	GM index total catch - Obs	Up (all species)			Nil (all species)		
Catch composition	GM index HMS shark catch - TLCER	Up (all species)			Up (all species)		
Catch composition	GM index HMS shark catch - Obs	Up (all species)			Nil (all species)		
Standardised CPUE	CPUE - TLCER	Up	Nil	Up	Up	Nil	Nil
Standardised CPUE	CPUE - Obs	Up	Nil	Nil	Up	Nil	Nil
Sex ratio	Proportion males	Nil	Nil	Nil	Nil	Nil	NA
Size composition	Median length - Males	Nil	Nil	Nil	Nil	Nil	NA
Size composition	Median length - Females	Nil	Nil	Nil	Nil	Nil	NA



Porbeagle shark distribution indicators. Proportions of 0.5 degree rectangles having CPUE greater than 1 per 1000 hooks, and proportions of rectangles having zero catches, for North and South regions by fishing year, based on estimated catches (processed and discarded combined) reported on TLCERs. North region comprises Fisheries Management Areas (FMAs) 1, 2, 8, and 9, and South region comprises FMAs 5 and 7.



Standardised CPUE indices for commercial TLCER (Japan South and North) and observer datasets (all New Zealand).

Fishery and Stock Trends	
Recent Trend in Biomass or Proxy	Appears to be increasing
Recent Trend in Fishing Intensity or Proxy	Appears to be decreasing
Other Abundance Indices	-
Trends in Other Relevant Indicator or Variables	Catches in New Zealand increased from the late 1980s to a peak in 1998/99 of 301 t, then declined to 41 t in 2007-08, and have remained less than 100 t since.

Projections and Prognosis		
Stock Projections or Prognosis	The stock is likely to increase if effort remains at current levels.	
Probability of Current Catch or TACC causing Biomass to remain below or to decline below Limits	Soft Limit: Unknown Hard Limit: Unknown	
Probability of Current Catch or TACC causing Overfishing to continue or to commence	Unknown	
Assessment Methodology and Evaluation		
Assessment Type	Level 2- Partial Quantitative Stock Assessment: Standardised CPUE indices and other fishery indicators	
Assessment Method	Indicator analyses	
Assessment Dates	Latest assessment: 2014	Next assessment: Unknown
Overall assessment quality rank	1 – High Quality	
Main data inputs (rank)	- Distribution - Species composition - Size and sex ratio - Catch per unit effort	1 – All High quality
Data not used (rank)	N/A	
Changes to Model Structure and Assumptions	-	
Major Sources of Uncertainty	Historical catch recording before 2005 may not be accurate.	

Qualifying Comments
Relative to a wide range of shark species, the productivity of porbeagle sharks is very low. Females have a high age-at-maturity, high longevity (and therefore low natural mortality rate) and low annual fecundity. The low fecundity and high longevity are cause for strong concern,

as the ability of the stock to replace sharks removed by fishing is very limited.
Fishery Interactions
Interactions with protected species are known to occur in the longline fisheries of the South Pacific, particularly south of 30°S. Seabird bycatch mitigation measures are required in the New Zealand and Australian EEZs and through the WCPFC Conservation and Management Measure CMM2007-04. Sea turtles are also incidentally captured in longline gear; the WCPFC is attempting to reduce sea turtle interactions through Conservation and Management Measure CMM2008-03.

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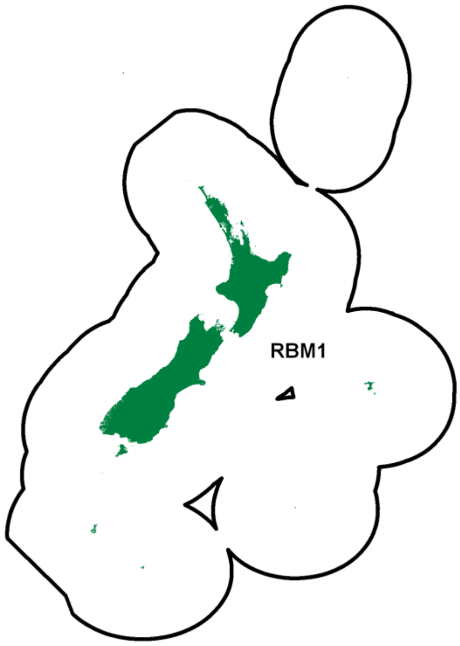
RAY'S BREAM (RBM)

(Brama brama)



1. FISHERY SUMMARY

Ray's bream (*Brama brama*) was introduced into the QMS on 1 October 2004 under a single QMA, RBM 1, with allowances, TACC and TAC in Table 1.

Table 1: Recreational and Customary non-commercial allowances, TACC and TAC (all in tonnes) for Ray's bream.

Fishstock	Recreational Allowance	Customary non-commercial Allowance	Other mortality	TACC	TAC
RBM 1	10	5	50	980	1045

At least two closely related species (*Brama brama* and *Brama australis*) are thought to be caught in New Zealand fisheries. Southern Ray's bream (*Brama australis*), which is difficult to distinguish using external features from *B. Brama*, has been reported in both catch statistics and research surveys but the actual proportions of the two species in the catch is unknown. A third closely related species, bronze bream (*Xenobrama microlepis*), is more easily distinguished from the other two, but is also likely to have been recorded as Ray's bream in catch statistics.

1.1 Commercial fisheries

Ray's bream is a highly migratory species and has a wide distribution, being found throughout the subtropical to sub-Antarctic waters across the whole South Pacific between New Zealand and Chile. The catch of Ray's bream, while fluctuating, appeared to be have been declining within New Zealand fisheries waters, from a high of 1001 t in 2000–01 to 143 t in 2011–12, followed by a larger catch of 823 t in 2012-13 (Table 3). Licensed fish receiver returns indicate between 119 and 815 t were processed for the same period.

Based on records since 2003–04, most (46%) Ray's bream is caught by mid-water trawl. Bottom trawling accounts for 27% of the total, surface longlining 18%, trolling 5% and bottom longlining 3%. Ray's bream is caught by mid-water trawlers in all FMAs around the South Island, with the largest amount in mid-water trawls being taken from Stewart-Snares shelf (FMA 5) and the Chatham Rise (FMA 3). The major catches by bottom trawling have occurred on the Chatham

Rise (FMA 3). Ray's bream is taken on surface tuna longlines on the east coast of the North Island, especially in the Bay of Plenty-East Cape (FMA 1). Most of the South Island longline catch comes from the west coast in FMAs 5 and 7. It is also taken by tuna trolling, especially on the west coast of the South Island (FMA 7). While observer coverage of the troll fleet is limited (0.5% of fishing days), observer records for the troll vessels have identified 100% of the Ray's bream in the troll catch as *B. Brama*. Figure 1 shows historical landings and longline fishing effort for the two Ray's bream fisheries.

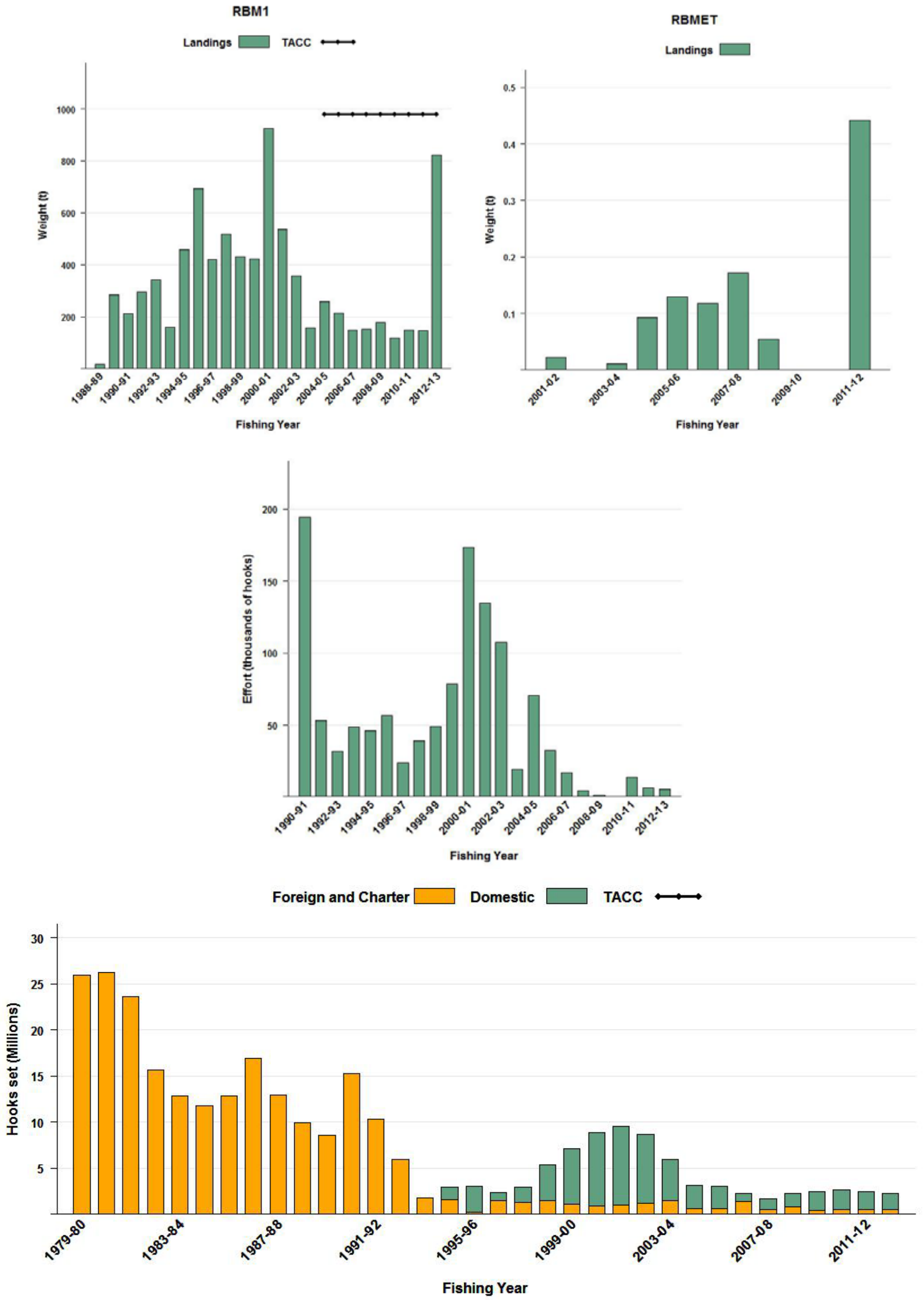


Figure 1: [Top] Ray's Bream catch from 1988–89 to 2012–13 within New Zealand waters (RBM 1) and 2001-02 to 2012-13 on the high seas (RBM ET). Fishing effort (number of hooks set) for high seas New Zealand flagged surface longline vessels from 1990–91 to 2012–13. [Bottom] Fishing effort (number of hooks set) for all domestic vessels (including effort by foreign vessels chartered by New Zealand fishing companies) from 1979–80 to 2012–13.

Table 2: Reported commercial landings and discards (t) of Ray's bream from CELRs and CLRs, and LFRRs (processor records) by fishing year.

	Reported by fishers			
	CELR and CLR		Total	Processed
Year	Landed	Discarded	reported	LFRR
1988–89	9	0	9	16
1989–90	328	< 1	328	284
1990–91	239	< 1	239	211
1991–92	297	< 1	297	295
1992–93	340	1	341	342
1993–94	151	3	154	160
1994–95	462	8	470	460
1995–96	717	3	720	693
1996–97	356	7	362	421
1997–98	546	8	554	520
1998–99	425	10	435	431
1999–00	444	23	467	423
2000–01	941	60	1 001	926

Table 3: LFRR and MHR data on Ray's bream catches by fishing year.

Year	LFRR Data	MHR Data
2001–02	541	536
2002–03	347	357
2003–04	154	157
2004–05	257	259
2005–06	212	215
2006–07	149	149
2007–08	149	152
2008–09	176	179
2009–10	119	119
2010–11	137	150
2011–12	143	147
2012–13	815	823

The majority of Ray's bream are caught in the New Zealand squid, hoki and Jack mackerel mid-water trawl fisheries with 11% of the Ray's bream landings coming from the Southern bluefin target surface longline fishery with small amounts coming from a range of other fisheries (Figure 2). Ray's bream make up less than 1% of the surface longline catch by weight (Figure 3). Most of the New Zealand Ray's bream catch is landed on the west coast of the South Island and sub-Antarctic islands (Figure 4).

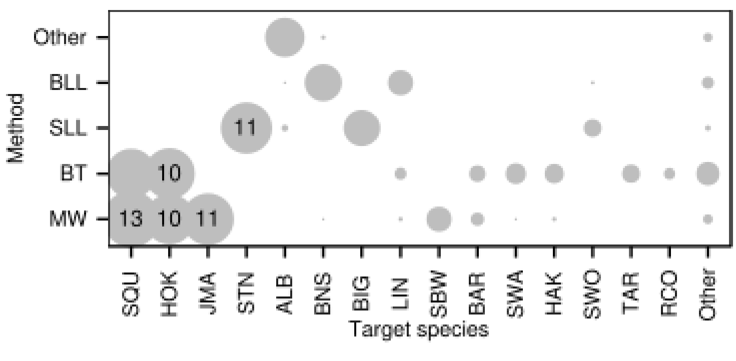


Figure 2: A summary of the proportion of landings of Ray's bream taken by each target fishery and fishing method. The area of each circle is proportional to the percentage of landings taken using each combination of fishing method and target species. The number in the circle is the percentage. SLL = surface longline MW = mid-water trawl, BLL = bottom longline, BT = bottom trawl (Bentley et al 2013).

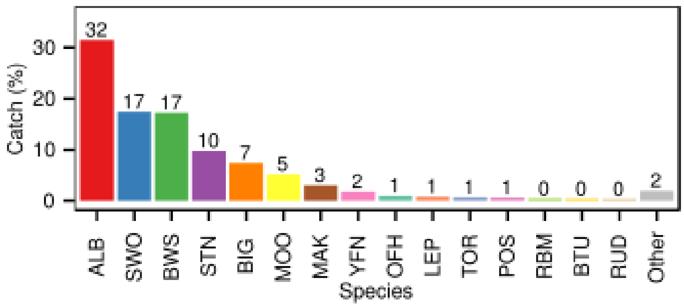


Figure 3: A summary of species composition of the reported surface longline catch. The percentage by weight of each species is calculated for all surface longline trips (Bentley et al 2013).

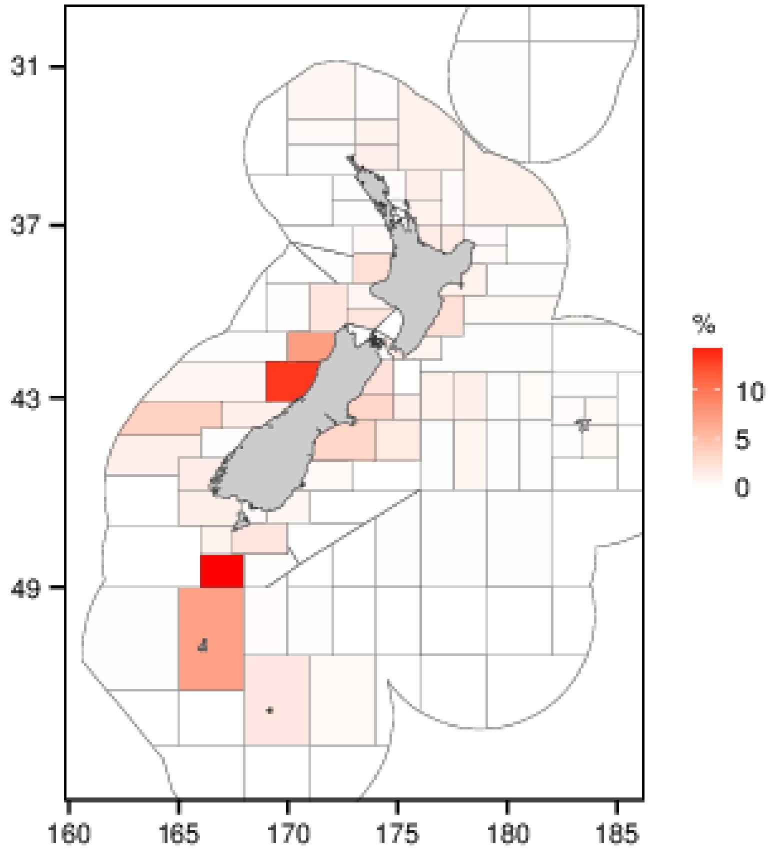


Figure 4: Distribution of catch of Ray's bream by statistical area for all years and all fishing gears. (Bentley et al 2013).

Across all fleets of the longline fishery, most of the Ray's bream were alive when brought to the side of the vessel (95%) (Table 4). The domestic fleets retain around 95–99% of their Ray's bream catch, while the foreign charter fleet retained 97–99% of their Ray's bream catch (Table 5).

Table 4: Percentage of Ray's bream (including discards) that were alive or dead when arriving at the longline vessel and observed during 2006–07 to 2009–10, by fishing year, fleet and region. Small sample sizes (number observed < 20) were omitted (Griggs & Baird 2013).

Year	Fleet	Area	% alive	% dead	Number
2006–07	Charter	North	87.0	13.0	215
		South	96.0	4.0	10 350
	Domestic	North	65.8	34.2	442
	Total		**94.6**	**5.4**	**11 019**
2007–08	Charter	South	95.7	4.3	3 680
	Domestic	North	70.2	29.8	151
	Total		**94.6**	**5.4**	**3 831**
2008–09	Charter	North	90.1	9.9	313
		South	97.9	2.1	4 277
	Domestic	North	78.8	21.2	551
		South	94.1	5.9	34
	Total		**95.4**	**4.6**	**5 175**
2009–10	Charter	South	96.3	3.7	3 259
	Domestic	North	85.6	14.4	264
		South	92.0	8.0	88
	Total		**95.5**	**4.5**	**3 611**
Total all strata			**94.9**	**5.1**	**23 636**

Table 5: Percentage of Ray's bream that were retained, or discarded or lost, when observed on a longline vessel during 2006–07 to 2009–10, by fishing year and fleet. Small sample sizes (number observed < 20) omitted (Griggs & Baird 2013).

Year	Fleet	% retained	% discarded or lost	Number
2006–07	Charter	96.8	3.2	11 744
	Domestic	95.7	4.3	442
	Total	**96.8**	**3.2**	**12 198**
2007–08	Charter	96.8	3.2	3 714
	Domestic	98.7	1.3	152
	Total	**96.9**	**3.1**	**3 866**
2008–09	Charter	98.7	1.3	4 646
	Domestic	98.3	1.7	585
	Total	**98.7**	**1.3**	**5 231**
2009–10	Charter	98.8	1.2	3 291
	Domestic	95.3	4.7	361
	Total	**98.4**	**1.6**	**3 652**
Total all strata		**97.4**	**2.6**	**24 947**

1.3 Recreational fisheries
Recreational fishers take Ray’s bream infrequently, generally as bycatch when targeting bluenose, hapuku and bass over deep reefs. The recreational harvest is assumed to be low, and is likely to be insignificant in the context of the total landings.

1.4 Customary non-commercial fisheries
There is no quantitative information available to allow the estimation of the harvest of Ray’s bream by customary fishers, however, the harvest is assumed to be insignificant in the context of the commercial landings.

1.5 Illegal catch
There is no known illegal catch of Ray’s bream.

1.6 Other sources of mortality
Ray’s bream is a desirable species, and only a small percentage (about 1–5% annually) has been reported or observed as having been discarded. Most of the trawl catch of Ray’s bream that is reported on CELR and CLR forms is retained. Most of the discarding appears to occur in the tuna fisheries, but these fisheries only take a small proportion of the total catch of Ray’s bream. There may be some unobserved shark and cetacean depredation of longline caught Ray’s bream.

2. BIOLOGY

Until recently, little was known about the biology of Ray’s bream in New Zealand waters. A 2004 study examined growth rates, natural mortality and maturity for Ray’s bream. Unfortunately, the actual species examined in this study could not be determined. It is possible that more than one species was involved, and the one (or more) species may not have been representative of the New Zealand catch recorded as Ray’s bream. Until further samples are collected, the identification cannot be confirmed, but it is likely that the study was based wholly or partly on Southern Ray’s bream (*Brama australis*).

It is expected that the main biological characteristics of Ray’s bream will be similar to Southern Ray’s bream, so the general findings of the recent study are reported here (Table 6). The small otoliths proved to be extremely difficult to age; notwithstanding this, Southern Ray’s bream appear to have rapid initial growth, reaching 40–50 cm in 3–5 years, with little increase in length after this time. The maximum age observed was 25 years.

Table 6: Estimates of biological parameters.

Parameter		Estimate		Source
1. Weight = a·(length)^b (Weight in t, length in cm)				
	Both sexes	a = 5.31 x10^{-9}	b = 3.320	Livingston et al 2004

3. STOCKS AND AREAS

Ray’s bream probably come from a wide-ranging single stock found throughout the South Pacific Ocean and southern Tasman Sea. The catch of Ray’s bream elsewhere in the South Pacific needs to be considered when assessing the status of Ray’s bream within New Zealand’s fisheries waters.

4. ENVIRONMENTAL AND ECOSYSTEM CONSIDERATIONS

This section was updated for the November 2014 Fishery Assessment Plenary after review by the Aquatic Environment Working Group. This summary is from the perspective of Ray’s bream but there is no directed fishery for them and the incidental catch sections below reflect the New Zealand longline fishery as a whole and are not specific to this species; a more detailed summary from an issue-by-issue perspective is available in the Aquatic Environment & Biodiversity Annual Review where the consequences are also discussed. (http://www.mpi.govt.nz/Default.aspx?TabId=126&id=2122) (Ministry for Primary Industries 2013a).

4.1 Role in the ecosystem

Ray's bream (*Brama brama*) is found in mid-water depths down to 1000 m. Ray's bream undertakes daily vertical migrations (Lobo & Erzini 2001) and is thought to feed opportunistically on small fish and cephalopods. It is known to be predated on by deepwater sharks such as the deepwater dogfish species *Centrophorus squamosus* and *Centroscymnus owstonii*, and the school shark *Galeorhinus galeus* (Dunn et al 2010).

4.2 Incidental catch (seabirds, sea turtles and mammals)

The protected species, capture estimates presented here include all animals recovered onto the deck (alive, injured or dead) of fishing vessels but do not include any cryptic mortality (e.g., seabirds caught on a hook but not brought onboard the vessel).

4.2.1 Seabird bycatch

Between 2002–03 and 2012–13, there were 818 observed captures of birds across other surface longline target fisheries (those not targeting albacore tuna, bigeye tuna, southern bluefin tuna, pacific bluefin tuna and swordfish).. Seabird capture rates since 2003 are presented in Table 7 and Figures 5 and 6. Seabird captures were more frequent off the south west coast of the South Island (Figure 7). Bayesian models of varying complexity dependent on data quality have been used to estimate captures across a range of methods (Richard & Abraham 2014). Observed and estimated seabird captures in albacore longline fisheries are provided in Table 8.

Through the 1990s the minimum seabird mitigation requirement for surface longline vessels was the use of a bird scaring device (tori line) but common practice was that vessels set surface longlines primarily at night. In 2007 a notice was implemented under s 11 of the Fisheries Act 1996 to formalise the requirement that surface longline vessels only set during the hours of darkness and use a tori line when setting. This notice was amended in 2008 to add the option of line weighting and tori line use if setting during the day. In 2011 the notices were combined and repromulgated under a new regulation (Regulation 58A of the Fisheries (Commercial Fishing) Regulations 2001) which provides a more flexible regulatory environment under which to set seabird mitigation requirements.

Risk posed by commercial fishing to seabirds has been assessed via a level 2 method which supports much of the NPOA-Seabirds 2013 risk assessment framework (MPI 2013b). The method used in the level 2 risk assessment arose initially from an expert workshop hosted by the Ministry of Fisheries in 2008. The overall framework is described in Sharp et al. (2011) and has been variously applied and improved in multiple iterations (Waugh et al. 2009, Richard et al. 2011, Richard & Abraham 2013, Richard et al. 2013 and Richard & Abraham in press). The method applies an "exposure-effects" approach where exposure refers to the number of fatalities is calculated from the overlap of seabirds with fishing effort compared with observed captures to estimate the species vulnerability (capture rates per encounter) to each fishery group. This is then compared to the population's productivity, based on population estimates and biological characteristics to yield estimates of population-level risk.

The 2014 iteration of the seabird risk assessment (Richard & Abraham in press) assessed other surface longline target fisheries (those not targeting albacore tuna, bigeye tuna, southern bluefin tuna, pacific bluefin tuna and swordfish) contribution to the total risk posed by New Zealand commercial fishing to seabirds (see Table 9). These target fisheries contribute 0.003 of PBR_1 to the risk to Southern Buller's albatross which was assessed to be at very high risk from New Zealand commercial fishing (Richard & Abraham in press).

Table 7: Number of observed seabird captures in the New Zealand surface longline fisheries, 2002–03 to 2012–13, by species and area. See glossary above for a description of the areas used for summarising the fishing effort and protected species captures. The risk ratio is an estimate of aggregate potential fatalities across trawl and longline fisheries relative to the Potential Biological Removals, PBR (from Richard and Abraham (2013) where full details of the risk assessment approach can be found). It is not an estimate of the risk posed by fishing for Ray's bream using longline gear but rather the total risk for each seabird species. Other data, version 20130305.

Albatross Species	Risk Ratio	Kermadec Islands	Northland and Hauraki	Bay of Plenty	East Coast North Island	Stewart Snares Shelf	Fiordland	West Coast South Island	West Coast North Island	Total
Salvin's	Very high	0	1	2	6	0	0	0	0	9
Southern Buller's	Very high	0	5	2	27	0	280	39	0	353
NZ white-capped	Very high	0	2	0	3	10	62	36	1	114
Northern Buller's	High	0	0	0	1	0	0	0	0	1
Gibson's	High	4	16	0	17	0	6	3	1	47
Antipodean	High	12	10	1	8	0	0	0	1	32
Northern royal	Medium	0	0	1	0	0	0	0	0	1
Southern royal	Medium	0	1	0	0	0	4	1	0	6
Campbell black-browed	Medium	2	10	2	29	0	3	3	1	50
Light-mantled sooty	Very low	0	0	0	0	0	0	1	0	1
Unidentified	N/A	38	2	0	2	0	0	0	1	43
Total	**N/A**	**56**	**47**	**8**	**93**	**10**	**355**	**83**	**5**	**657**
Other seabirds										
	Risk Ratio	Kermadec Islands	Northland and Hauraki	Bay of Plenty	East Coast North Island	Stewart Snares Shelf	Fiordland	West Coast South Island	West Coast North Island	Total
Black petrel	Very high	1	10	1	0	0	0	0	1	13
Flesh-footed shearwater	Very high	0	0	0	10	0	0	0	2	12
Cape petrel	High	0	0	0	2	0	0	0	0	2
Westland petrel	Medium	0	0	0	2	0	1	6	0	9
White-chinned petrel	Medium	2	3	3	3	1	20	3	3	38
Grey petrel	Medium	3	4	3	38	0	0	0	0	48
Grey-faced petrel	Very low	12	5	1	2	0	0	0	0	20
Sooty shearwater	Very low	1	0	0	8	3	1	0	0	13
Southern giant petrel	-	0	0	2	0	0	0	0	2	0
White-headed petrel	-	2	0	0	0	0	0	0	0	2
Unidentified	N/A	0	1	0	0	0	1	0	0	2
Total	**N/A**	**21**	**23**	**10**	**65**	**4**	**23**	**9**	**8**	**159**

Table 8: Effort, observed and estimated seabird captures by fishing year for the New Zealand surface longline fishery within the EEZ. For each fishing year, the table gives the total number of hooks; the number of observed hooks; observer coverage (the percentage of hooks that were observed); the number of observed captures; the capture rate (captures per thousand hooks); and the mean number of estimated total captures (with 95% confidence interval). Estimates are based on methods described in Thompson et al (2013) and are available via http://www.fish.govt.nz/en-nz/Environmental/Seabirds/. Estimates from 2002–03 to 2010–11 and preliminary estimates for 2012–13 are based on data version 20140131.

	Fishing effort			Observed captures		Estimated captures	
Fishing year	All hooks	Observed hooks	% observed	Number	Rate	Mean	95% c.i.
2002–2003	10 772 188	2 195 152	20.4	115	0.052	2 088	1 613–2 807
2003–2004	7 386 329	1 607 304	21.8	71	0.044	1 395	1 086–1 851
2004–2005	3 679 765	783 812	21.3	41	0.052	617	483–793
2005–2006	3 690 119	705 945	19.1	37	0.052	808	611–1 132
2006–2007	3 739 912	1 040 948	27.8	187	0.18	958	736–1 345
2007–2008	2 246 189	421 900	18.8	37	0.088	524	417–676
2008–2009	3 115 633	937 496	30.1	57	0.061	609	493–766
2009–2010	2 995 264	665 883	22.2	135	0.203	939	749–1 216
2010–2011	3 187 879	674 572	21.2	47	0.07	705	532–964
2011–2012	3 100 277	728 190	23.5	64	0.088	829	617–1 161
2012–2013†	2 862 182	560 333	19.6	27	0.048	783	567–1 144

†Provisional data, model estimates not finalised.

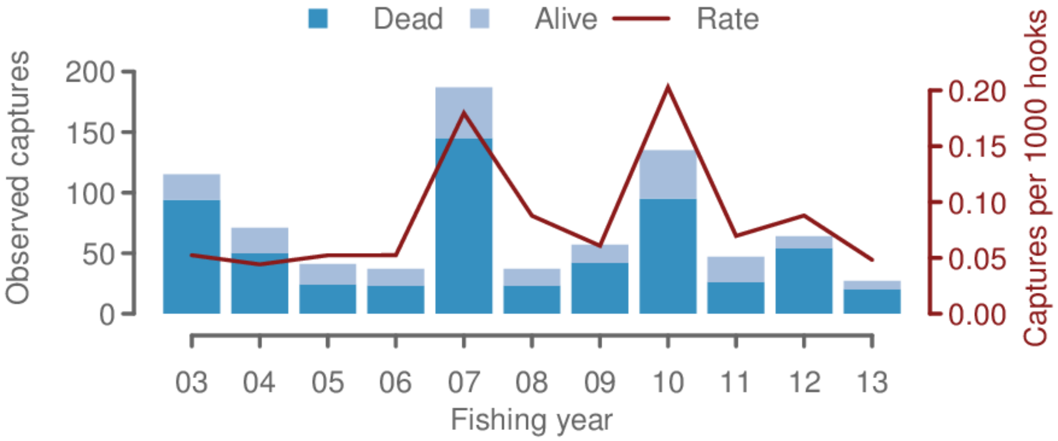


Figure 5: Observed captures of seabirds in the New Zealand surface longline fisheries from 2002–03 to 2012–13.

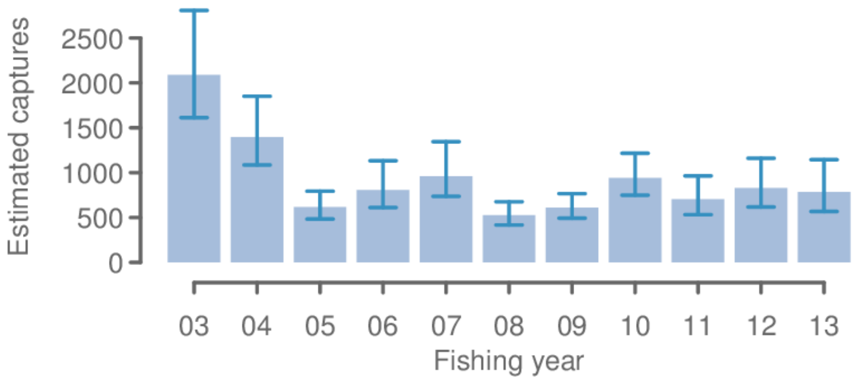


Figure 6: Estimated captures of seabirds in the New Zealand surface longline fisheries from 2002–03 to 2012–13.

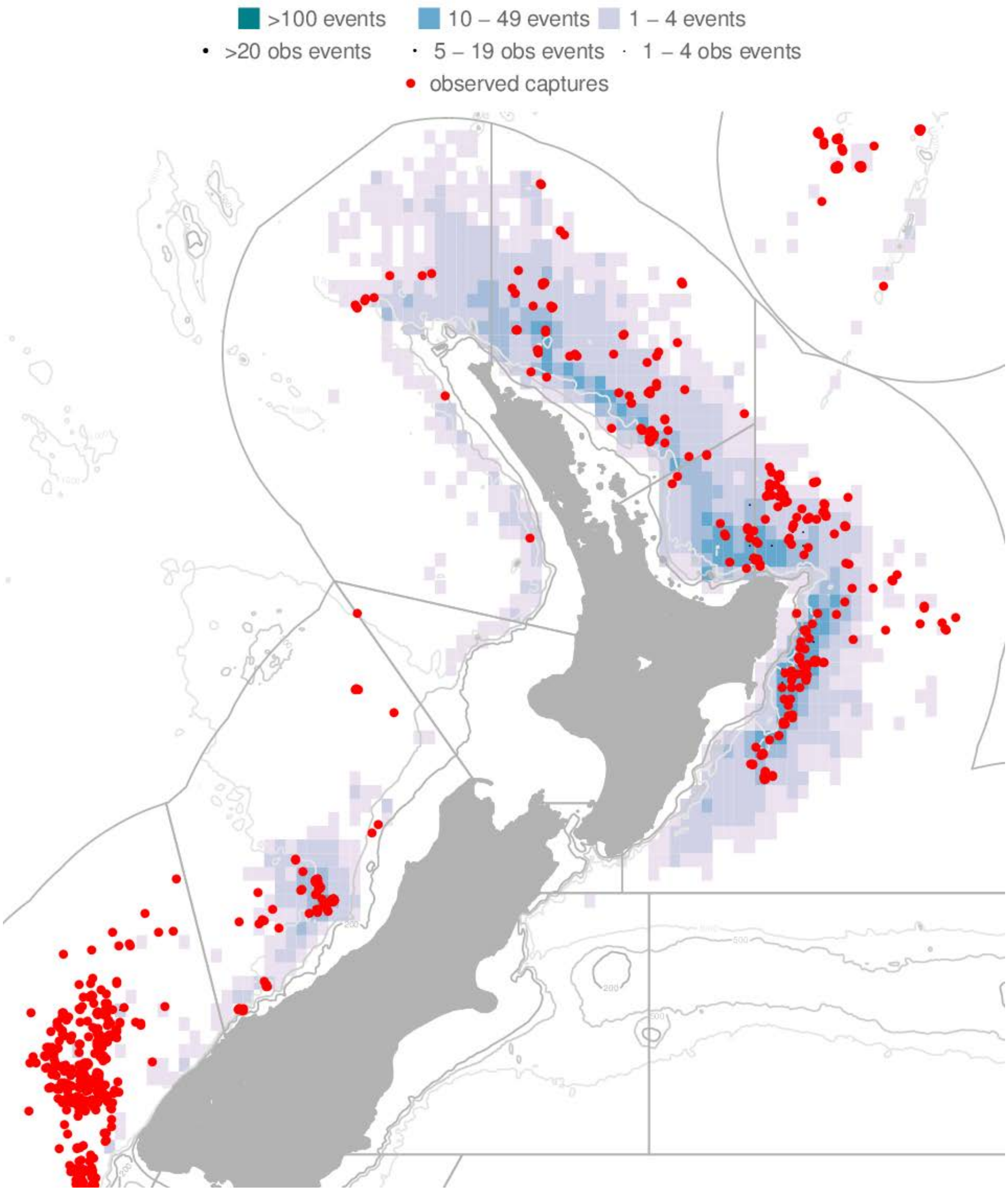


Figure 7: Distribution of fishing effort in the New Zealand surface longline fisheries and observed seabird captures, 2002–03 to 2012–13. Fishing effort is mapped into 0.2-degree cells, with the colour of each cell being related to the amount of effort. Observed fishing events are indicated by black dots, and observed captures are indicated by red dots. Fishing is only shown if the effort could be assigned a latitude and longitude, and if there were three or more vessels fishing within a cell. In this case, 89.4% of the effort is shown. See glossary for areas used for summarising the fishing effort and protected species captures.

Table 9: Risk ratio of seabirds predicted by the level two risk assessment for the other species target surface longline fisheries (those not targeting albacore tuna, bigeye tuna, southern bluefin tuna, pacific bluefin tuna and swordfish) and all fisheries included in the level two risk assessment, 2006–07 to 2012–13, showing seabird species with risk category of very or high, or a medium risk category and risk ratio of at least 1% of the total risk. The risk ratio is an estimate of aggregate potential fatalities across trawl and longline fisheries relative to the Potential Biological Removals, PBR_1 (from Richard and Abraham 2014 where full details of the risk assessment approach can be found). PBR_1 applies a recovery factor of 1.0. Typically a recovery factor of 0.1 to 0.5 is applied (based on the state of the population) to allow for recovery from low population sizes as quickly as possible. This should be considered when interpreting these results. The New Zealand threat classifications are shown (Robertson et al 2013 at http://www.doc.govt.nz/documents/science-and-technical/nztcs4entire.pdf)

	Risk ratio				
Species name	OTH target SLL	Total risk from NZ commercial fishing	% of total risk from NZ commercial fishing	Risk category	NZ Threat Classification
Black petrel	0.000	15.095	0.00	Very high	Threatened: Nationally Vulnerable
Salvin's albatross	0.000	3.543	0.00	Very high	Threatened: Nationally Critical
Southern Buller's albatross	0.003	2.823	0.10	Very high	At Risk: Naturally Uncommon
Flesh-footed shearwater	0.000	1.557	0.00	Very high	Threatened: Nationally Vulnerable
Gibson's albatross	0.000	1.245	0.00	Very high	Threatened: Nationally Critical
New Zealand white-capped albatross	0.000	1.096	0.01	Very high	At Risk: Declining
Chatham Island albatross	0.000	0.913	0.00	High	At Risk: Naturally Uncommon
Antipodean albatross	0.000	0.888	0.00	High	Threatened: Nationally Critical
Westland petrel	0.000	0.498	0.00	High	At Risk: Naturally Uncommon
Northern Buller's albatross	0.000	0.336	0.13	High	At Risk: Naturally Uncommon
Campbell black-browed albatross	0.000	0.304	0.00	High	At Risk: Naturally Uncommon
Stewart Island shag	0.000	0.301	0.00	High	Threatened: Nationally Vulnerable

4.2.2 Sea turtle bycatch

Between 2002–03 and 2012–13, there were 15 observed captures of sea turtles across all surface longline fisheries (Tables 10 and 11, Figure 8). Observer records documented all but one sea turtle as captured and released alive. Sea turtle capture distributions predominantly occur throughout the east coast of the North Island and Kermadec Island fisheries (Figure 9).

Table 10: Number of observed sea turtle captures in the New Zealand surface longline fisheries, 2002–03 to 2012–13, by species and area. Data from Thompson et al (2013), retrieved from http://data.dragonfly.co.nz/psc/. See glossary above for a description of the areas used for summarising the fishing effort and protected species captures.

Species	Bay of Plenty	East Coast North Island	Kermadec Islands	West Coast North Island	Total
Leatherback turtle	1	4	3	3	11
Green turtle	0	1	0	0	1
Unknown turtle	0	1	0	2	3
Total	1	6	3	5	15

Table 11: Effort and sea turtle captures in surface longline fisheries by fishing year. For each fishing year, the table gives the total number of hooks; the number of observed hooks; observer coverage (the percentage of hooks that were observed); the number of observed captures (both dead and alive); and the capture rate (captures per thousand hooks). For more information on the methods used to prepare the data see Thompson et al (2013).

	Fishing effort			Observed captures	
Fishing year	All hooks	Observed hooks	% observed	Number	Rate
2002–2003	10 772 188	2 195 152	20.4	0	0
2003–2004	7 386 329	1 607 304	21.8	1	0.001
2004–2005	3 679 765	783 812	21.3	2	0.003
2005–2006	3 690 119	705 945	19.1	1	0.001
2006–2007	3 739 912	1 040 948	27.8	2	0.002
2007–2008	2 246 189	421 900	18.8	1	0.002
2008–2009	3 115 633	937 496	30.1	2	0.002
2009–2010	2 995 264	665 883	22.2	0	0
2010–2011	3 187 879	674 572	21.2	4	0.006
2011–2012	3 100 277	728 190	23.5	0	0
2012–2013	2 862 182	560 333	19.6	2	0.004

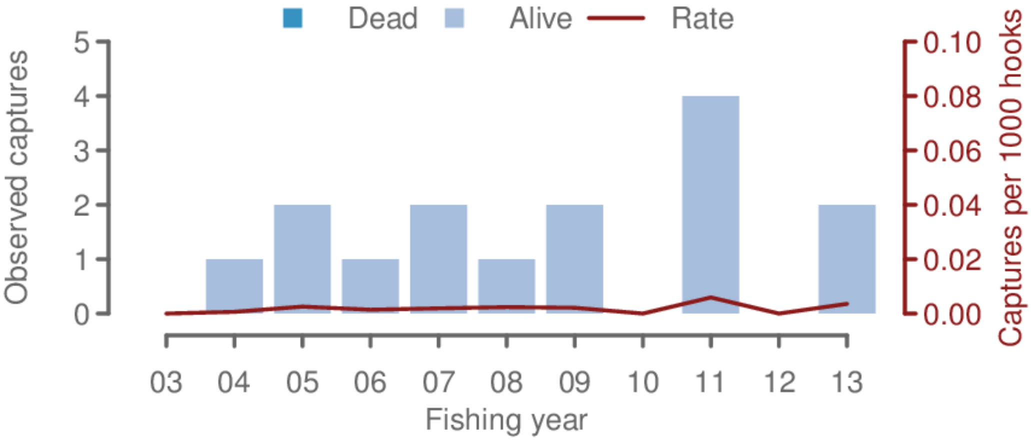


Figure 8: Observed captures of sea turtles in the New Zealand surface longline fisheries from 2002–03 to 2012–13.

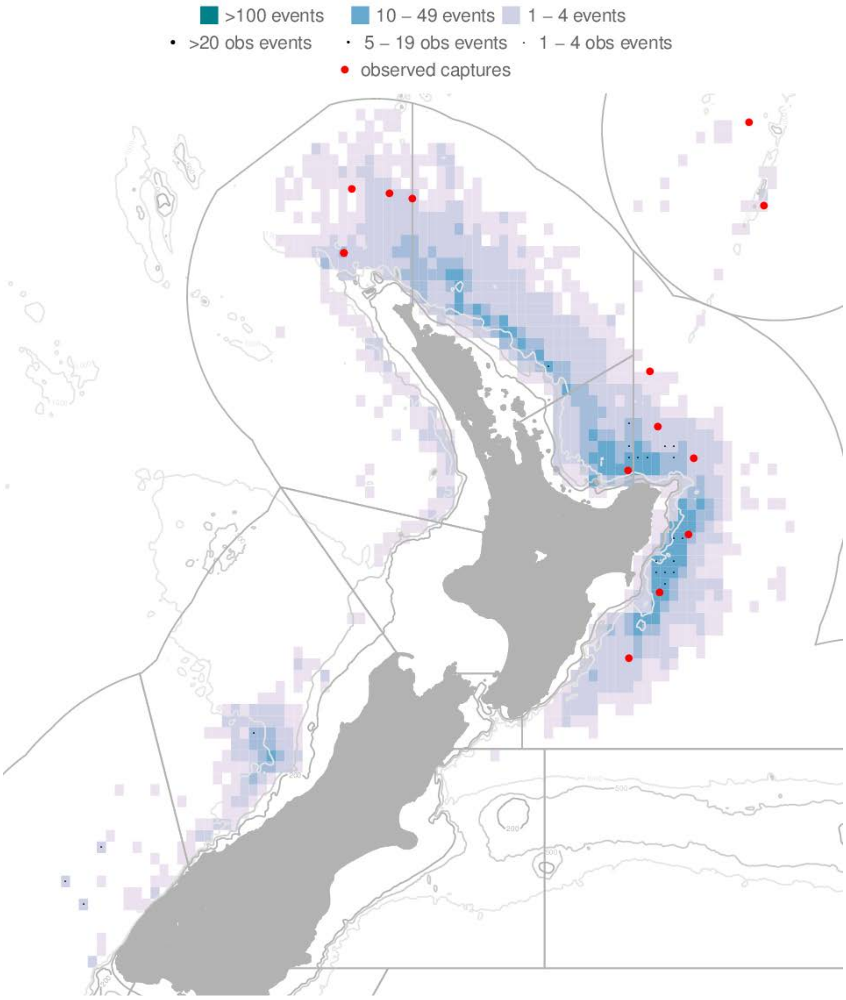


Figure 9: Distribution of fishing effort in the New Zealand surface longline fisheries and observed sea turtle captures, 2002–03 to 2012–13. Fishing effort is mapped into 0.2-degree cells, with the colour of each cell being related to the amount of effort. Observed fishing events are indicated by black dots, and observed captures are indicated by red dots. Fishing is only shown if the effort could be assigned a latitude and longitude, and if there were three or more vessels fishing within a cell. In this case, 89.4% of the effort is shown. See glossary for areas used for summarising the fishing effort and protected species captures.

4.2.3 Marine Mammals

4.2.3.1 Cetaceans

Cetaceans are dispersed throughout New Zealand waters (Perrin et al 2008). The spatial and temporal overlap of commercial fishing grounds and cetacean foraging areas has resulted in cetacean captures in fishing gear (Abraham & Thompson 2009, 2011).

Between 2002–03 and 2012–13, there were seven observed captures of whales and dolphins in surface longline fisheries. Observed captures included 5 unidentified cetaceans and 2 long-finned Pilot whales (Tables 12 and 13, Figure 10) (Thompson et al 2013). All captured animals recorded were documented as being caught and released alive (Thompson et al 2013). Cetacean capture distributions are more frequent off the east coast of the North Island (Figure 11).

Table 12: Number of observed cetacean captures in the New Zealand surface longline fisheries, 2002–03 to 2012–13, by species and area. Data from Thompson et al (2013), retrieved from http://data.dragonfly.co.nz/psc/. See glossary above for a description of the areas used for summarising the fishing effort and protected species captures.

Species	Bay of Plenty	East Coast North Island	Fiordland	Northland and Hauraki	West Coast North Island	West Coast South Island	Total
Long-finned pilot whale	0	1	0	0	0	1	2
Unidentified cetacean	1	1	1	1	1	0	5
Total	1	2	1	1	1	1	7

Table 13: Effort and captures of cetaceans in surface longline fisheries by fishing year. For each fishing year, the table gives the total number of hooks; the number of observed hooks; observer coverage (the percentage of hooks that were observed); the number of observed captures (both dead and alive); and the capture rate (captures per thousand hooks). For more information on the methods used to prepare the data, see Thompson et al (2013).

	Fishing effort			Observed captures	
Fishing year	All hooks	Observed hooks	% observed	Number	Rate
2002–2003	10 772 188	2 195 152	20.4	1	0
2003–2004	7 386 329	1 607 304	21.8	4	0.002
2004–2005	3 679 765	783 812	21.3	1	0.001
2005–2006	3 690 119	705 945	19.1	0	0
2006–2007	3 739 912	1 040 948	27.8	0	0
2007–2008	2 246 189	421 900	18.8	1	0.002
2008–2009	3 115 633	937 496	30.1	0	0
2009–2010	2 995 264	665 883	22.2	0	0
2010–2011	3 187 879	674 572	21.2	0	0
2011–2012	3 100 277	728 190	23.5	0	0
2012–2013	2 862 182	560 333	19.6	0	0

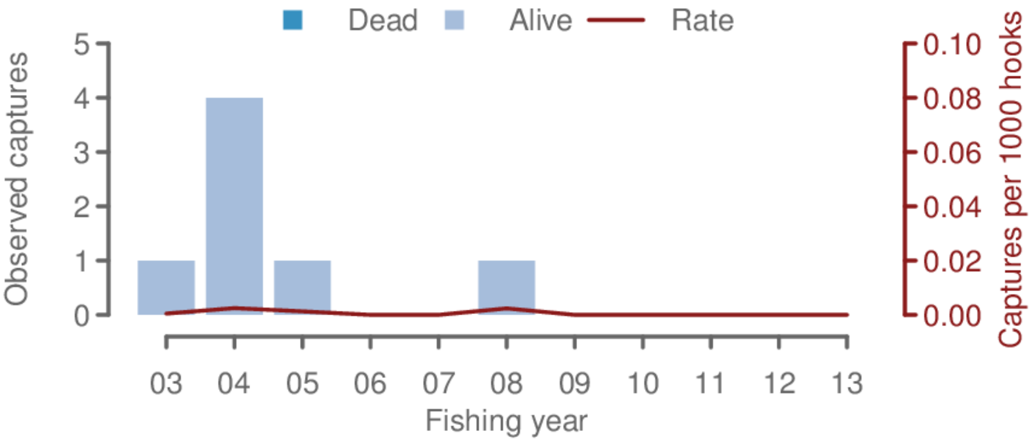


Figure 10: Observed captures of cetaceans in the New Zealand surface longline fisheries from 2002–03 to 2012–13.

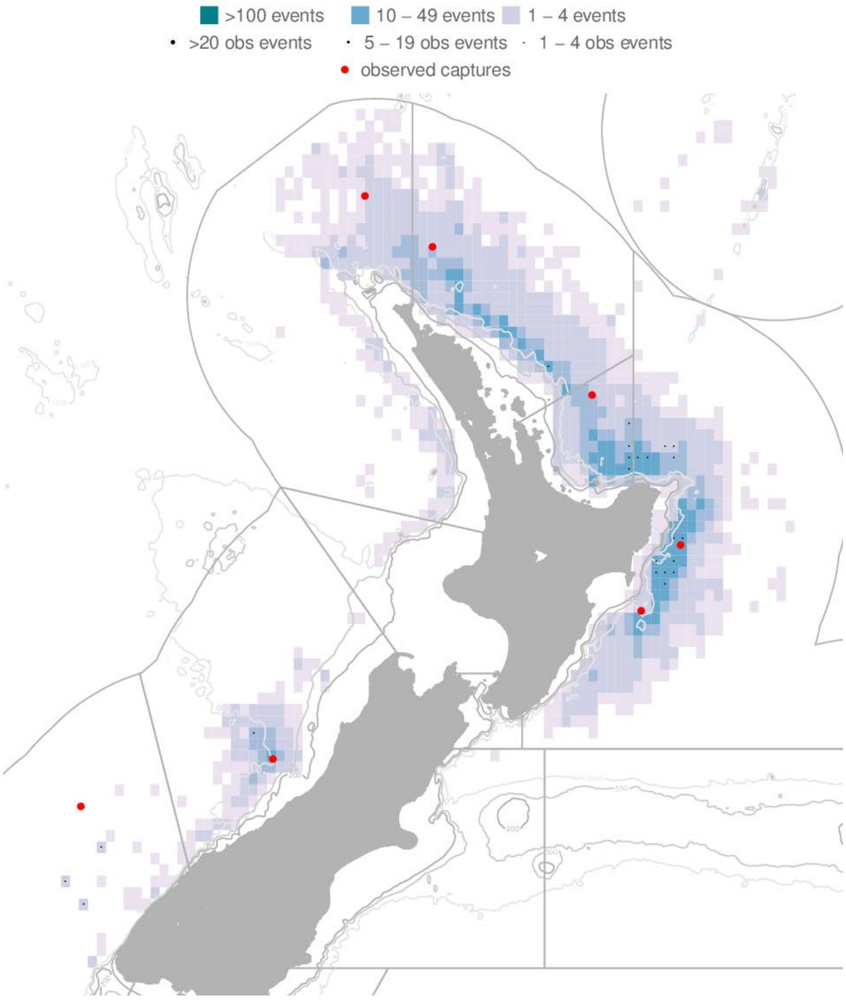


Figure 11: Distribution of fishing effort in the New Zealand surface longline fisheries and observed cetacean captures, 2002–03 to 2012–13. Fishing effort is mapped into 0.2-degree cells, with the colour of each cell being related to the amount of effort. Observed fishing events are indicated by black dots, and observed captures are indicated by red dots. Fishing is only shown if the effort could be assigned a latitude and longitude, and if there were three or more vessels fishing within a cell. In this case, 89.4% of the effort is shown. See glossary for areas used for summarising the fishing effort and protected species captures.

4.2.3.2 New Zealand fur seal bycatch

Currently, New Zealand fur seals are dispersed throughout New Zealand waters, especially in waters south of about 40º S to Macquarie Island. The spatial and temporal overlap of commercial fishing grounds and New Zealand fur seal foraging areas has resulted in New Zealand fur seal captures in fishing gear (Mattlin 1987, Rowe 2009). Most fisheries with observed captures occur in waters over or close to the continental shelf, which slopes steeply to deeper waters relatively close to shore, and thus rookeries and haulouts, around much of the South Island and offshore islands. Captures on longlines occur when the fur seals attempt to feed on the bait and fish catch during hauling. Most New Zealand fur seals are released alive, typically with a hook and short snood or trace still attached.

New Zealand fur seal captures in surface longline fisheries have been generally observed in waters south and west of Fiordland, but also in the Bay of Plenty-East Cape area when the animals have attempted to take bait or fish from the line as it is hauled. These capture rates include animals that are released alive (100% of observed surface longline capture in 2008–09; Thompson & Abraham 2010). Capture rates in 2011–12 and 2012-13 were higher than they were in the early 2000s (Figures 12 and 13). While fur seal captures have occurred throughout the

range of this fishery most New Zealand captures have occurred off the Southwest coast of the South Island (Figure 14). Between 2002–03 and 2012–13, there were 267 observed captures of New Zealand fur seal in surface longline fisheries (Tables 14 and 15).

Table 14: Number of observed New Zealand fur seal captures in the New Zealand surface longline fisheries, 2002–03 to 2012–13, by species and area. Data from Thompson et al (2013), retrieved from http://data.dragonfly.co.nz/psc/. See glossary above for a description of the areas used for summarising the fishing effort and protected species captures.

	Bay of Plenty	East Coast North Island	Fiordland	Northland and Hauraki	Stewart Snares Shelf	West Coast North Island	West Coast South Island	Total
New Zealand fur seal	11	33	179	4	4	2	34	267

Table 15: Effort and captures of New Zealand fur seal in the New Zealand surface longline fisheries by fishing year. For each fishing year, the table gives the total number of hooks; the number of observed hooks; observer coverage (the percentage of hooks that were observed); the number of observed captures (both dead and alive); and the capture rate (captures per thousand hooks). Data from Thompson et al (2013), retrieved from http://data.dragonfly.co.nz/psc/. Estimates from 2002–03 to 2010–11 and preliminary estimates for 2012–13 are based on data version 20140131.

	Fishing effort			Observed captures		Estimated captures	
Fishing year	All hooks	Observed hooks	% observed	Number	Rate	Mean	95% c.i.
2002–2003	10 772 188	2 195 152	20.4	56	0.026	299	199–428
2003–2004	7 386 329	1 607 304	21.8	40	0.025	134	90–188
2004–2005	3 679 765	783 812	21.3	20	0.026	66	38–99
2005–2006	3 690 119	705 945	19.1	12	0.017	47	23–79
2006–2007	3 739 912	1 040 948	27.8	10	0.010	32	14–55
2007–2008	2 246 189	421 900	18.8	10	0.024	40	19–68
2008–2009	3 115 633	937 496	30.1	22	0.023	53	29–81
2009–2010	2 995 264	665 883	22.2	19	0.029	77	43–121
2010–2011	3 187 879	674 572	21.2	17	0.025	64	35–101
2011–2012	3 100 277	728 190	23.5	40	0.055	140	92–198
2012–2013†	2 862 182	560 333	19.6	21	0.037	110	65–171

†Provisional data, model estimates not finalised.

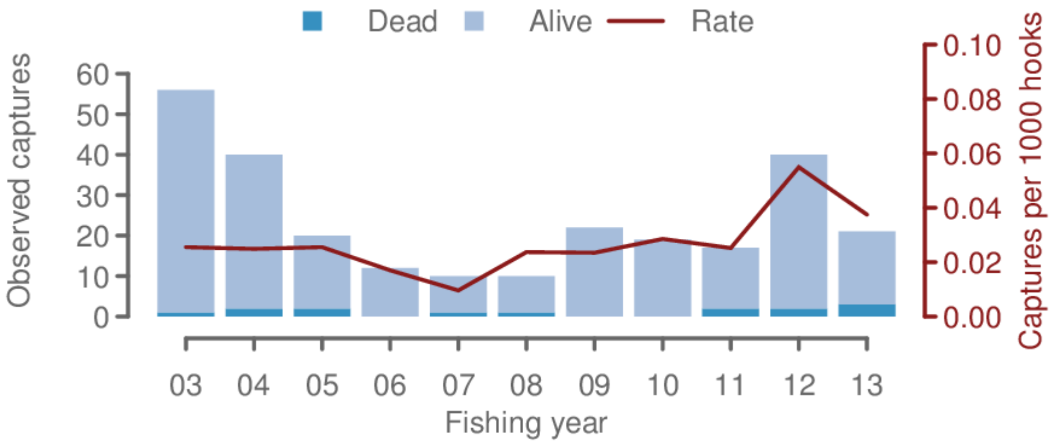


Figure 12: Observed captures of New Zealand fur seal in the New Zealand surface longline fisheries from 2002–03 to 2012–13.

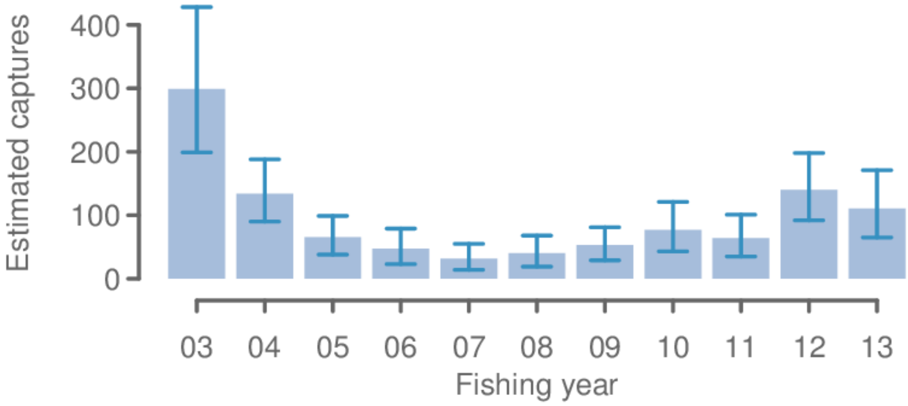


Figure 13: Observed and estimated captures of New Zealand fur seal in the New Zealand surface longline fisheries from 2002–03 to 2012–13.

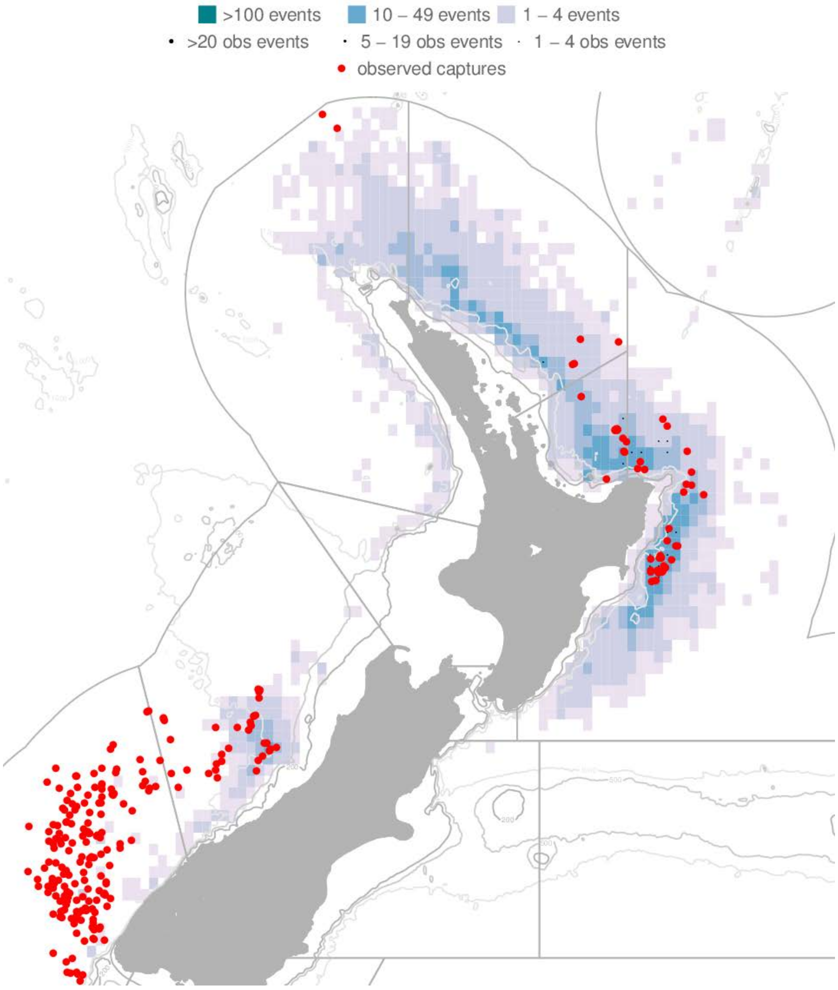


Figure 14: Distribution of fishing effort in the New Zealand surface longline fisheries and observed New Zealand fur seal captures, 2002–03 to 2012–13. Fishing effort is mapped into 0.2-degree cells, with the colour of each cell being related to the amount of effort. Observed fishing events are indicated by black dots, and observed captures are indicated by red dots. Fishing is only shown if the effort could be assigned a latitude and longitude, and if there were three or more vessels fishing within a cell. In this case, 89.4% of the effort is shown. See glossary for areas used for summarising the fishing effort and protected species captures.

4.3 Incidental fish bycatch

Observer records indicate that a wide range of species are landed by the longline fleets in New Zealand fishery waters. Blue sharks are the most commonly landed species (by number), followed by Ray’s bream (Table 16). Southern bluefin tuna and albacore tuna are the only target species that occur in the top five of the frequency of occurrence.

Table 16: Total estimated catch (numbers of fish) of common bycatch species in the New Zealand longline fishery as estimated from observer data from 2009 to 2013. Also provided is the percentage of these species retained (2013 data only) and the percentage of fish that were alive when discarded, N/A (none discarded).

Species	2010	2011	2012	2013	% retained (2013)	discards % alive (2013)
Blue shark	66113	53432	132925	158736	45.2	97.4
Lancetfish	43425	37305	7866	19172	0.1	37.6
Rays bream	20041	18453	19918	13568	97.4	4.2
Porbeagle shark	4679	9929	7019	9805	34.0	79.8
Mako shark	4490	9770	3902	3981	35.5	84.9
Moonfish	5398	3418	2363	2470	99.0	0.0
Escolar	1539	6602	2181	2088	30.2	76.3
Sunfish	3148	3773	3265	1937	2.7	100.0
Pelagic stingray	1983	4090	712	1199	1.0	97.0
Butterfly tuna	1158	909	713	1030	48.1	11.1
Deepwater dogfish	377	548	647	743	1.2	88.5
Oilfish	886	1747	509	386	26.5	72.2
Rudderfish	326	338	491	362	13.0	80.0
Thresher shark	209	349	246	256	33.3	75.0
Skipjack tuna	91	255	123	240	100.0	N/A
Dealfish	1160	223	372	237	1.7	25.1
Striped marlin	471	175	124	182	0.0	44.4
Big scale pomfret	505	139	108	67	88.2	100.0
School shark	62	49	477	21	100.0	N/A

4.4 Benthic interactions

N/A

4.5 Key environmental and ecosystem information gaps

Cryptic mortality is unknown at present but developing a better understanding of this in future may be useful for reducing uncertainty of the seabird risk assessment and could be a useful input into risk assessments for other species groups.

The survival rates of released target and bycatch species is currently unknown.

Observer coverage in the New Zealand fleet is not spatially and temporally representative of the fishing effort.

5. STOCK ASSESSMENT

No assessments are available for Ray’s bream; therefore estimates of biomass and yield are not available.

5.1 Estimates of fishery parameters and abundance

A time series of relative abundance estimates is available from the Chatham Rise trawl survey, but these estimates may not be a reliable index of relative abundance because Ray’s bream are thought to reside in the mid-water and their vulnerability to the trawl survey gear is unknown, and could be extremely low. Similarly, a time series of unstandardised CPUE from the tuna longline fishery is highly variable and may not reflect relative abundance.

CPUE estimates were calculated for the longline fishery by each fleet and area stratum in which eight or more sets were observed and at least 2% of the hooks were observed (Griggs & Baird 2013). CPUE estimates were calculated for Ray's bream for each fleet and area in 2006–07 to 2009–10 and added to the time series for 1988–89 to 2005–06 and these are shown in Figure 13 (Griggs & Baird 2013). The CPUE results from the Domestic fleet should be interpreted with caution due to the lower observer coverage of this fleet. CPUE estimates for the Charter fleet can be considered reliable from 1992–93 onwards. CPUE of Ray's bream, was highest in the South and for the Charter fleet. CPUE of Ray's bream increased to a peak in 2004–05, and remained high but has since decreased in the most recent years. However, as the surface longline catch of Ray's bream accounts for only a small proportion of the catch the longline CPUE (Figure 15) is unlikely to be sufficient to represent stock status and trends in abundance for the stock as a whole.

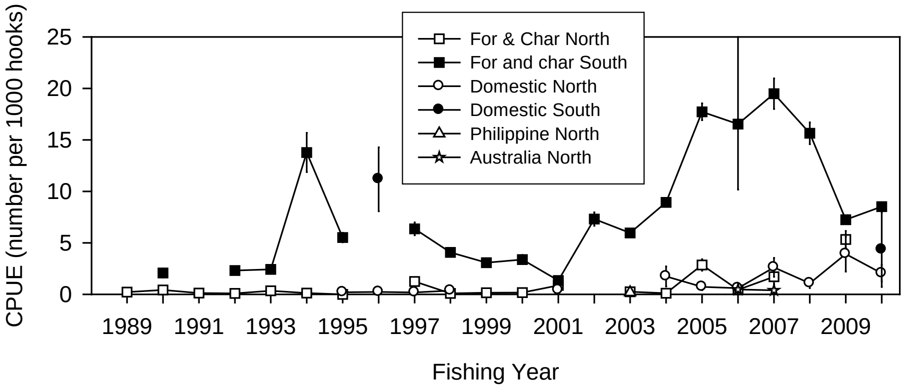


Figure 15: Annual variation in Ray's bream CPUE by fleet and area. Plotted values are the mean estimates with 95% confidence limits. Fishing year 1989 = October 1988 to September 1989 (Griggs & Baird 2013).

5.2 Biomass estimates

No biomass estimates are available for Ray's bream.

5.3 Other yield estimates and stock assessment results

There are no other yield estimates or stock assessment results available for Ray's bream.

5.4 Other factors

At least three closely related species are thought to be caught in New Zealand fisheries. Two species from the genus *Brama*, Ray's bream (*Brama brama*) and southern Ray's bream (*Brama australis*), are difficult to distinguish from external features and have been reported together in both catch statistics and research survey data in unknown ratios. A third closely related species, bronze bream (*Xenobrama microlepis*), is more easily distinguished from the other two, but is also likely to have been recorded as Ray's bream in catch statistics.

As none of the reported catch is from target fishing, the quota allocated under the QMS system will cover bycatch of mid-water trawl fisheries for squid, hoki, and jack mackerels, and target tuna longline fisheries.

The distributions of Ray's bream for each year in the North and South regions are shown in Figure 14. Ray's bream are usually kept whole and not sexed, but in 2006–07 and 2009–10 fish were further processed and the fish were sexed, and distributions are shown for 2006–07 and 2009–10 by region and sex. There are differences in the North/South distributions, with fish from the South being larger, but the distributions for males and females are similar (Figure 16). Female

Ray's bream mature at about 43 cm (Francis et al 2004), and most females were probably mature (78.7% over the four year period).

It is not known if observers are distinguishing Ray's bream from Southern Ray's bream (*Brama australis*) and it is possible that there are two species with different distributions. However observer training and fish identification guides now used by the observers should allow for correct identification and as a result the incidents of misidentification in recent years is likely to be low.

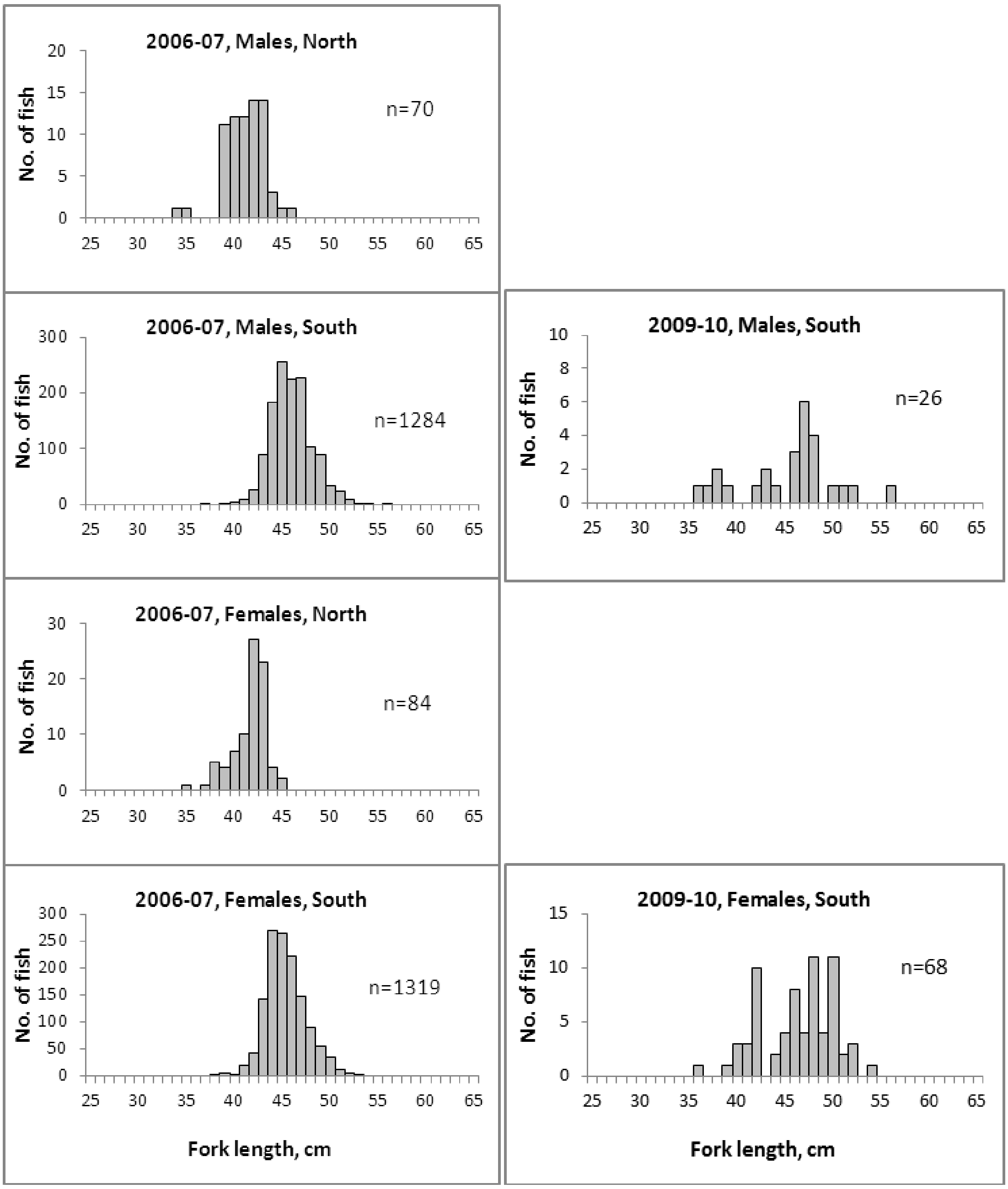


Figure 16: Length-frequency distributions of Ray's bream by fishing year, sex, and region. Sample sizes of less than 20 fish not shown (Griggs & Baird 2013). [Continued on next page]

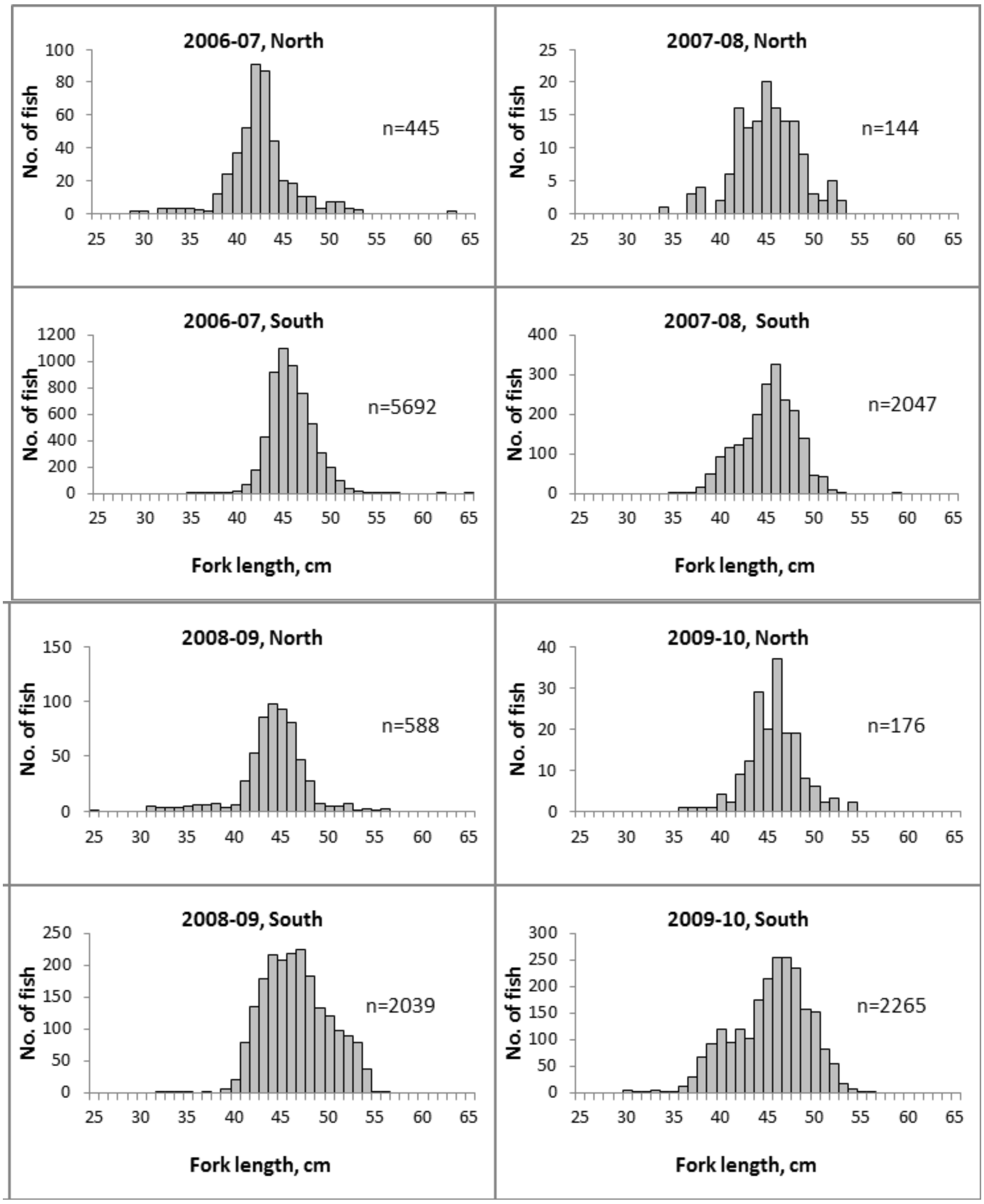


Figure 16 [continued]:

STATUS OF THE STOCKS

Stock structure assumptions

RBM 1 is assumed to be part of the wider South Western Pacific Ocean stock but the assessment below relates only to the New Zealand component of that stock.

Stock Status	
Year of Most Recent Assessment	No assessment
Assessment Runs Presented	-
Reference Points	Target: Not established Soft Limit: Not established but HSS default of 20% SB_0 assumed

	Hard Limit: Not established but HSS default of 10% SB_0 assumed Overfishing threshold: Not established
Status in relation to Target	Unknown
Status in relation to Limits	Unknown
Status in relation to Overfishing	Unknown

Fishery and Stock Trends	
Recent Trend in Biomass or Proxy	Unknown
Recent Trend in Fishing Intensity or Proxy	Unknown
Other Abundance Indices	Catches in New Zealand increased from the late 1980s to 2000 but have declined from highs of 1001 t in the early 2000s to 150 t in 2010–11.
Trends in Other Relevant Indicator or Variables	Unknown

Projections and Prognosis		
Stock Projections or Prognosis	Unknown	
Probability of Current Catch or TACC causing Biomass to remain below or to decline below Limits	Soft Limit: Unknown Hard Limit: Unknown	
Probability of Current Catch or TACC causing Overfishing to remain or to commence	Unknown	
Assessment Methodology and Evaluation		
Assessment Type	Level 4: Low information evaluation - There are only data on catch and TACC, with no other fishery indicators.	
Assessment Method	-	
Assessment Dates	Latest assessment: none	Next assessment: Unknown
Overall assessment quality rank	N/A	
Main data inputs (rank)	-	
Data not used (rank)	-	
Changes to Model Structure and Assumptions	-	
Major Sources of Uncertainty	-	

Qualifying Comments
There is no target fishery for Ray's bream but it is a bycatch in mid-water trawl, bottom trawl, surface longlining, trolling and bottom longlining.

Fishery Interactions
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7. FOR FURTHER INFORMATION

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New Zealand Government

Ministry for Primary Industries
Manatū Ahu Matua
Pastoral House
25 The Terrace
PO Box 2526, Wellington, 6140
New Zealand
www.mpi.govt.nz