Introduction

This report summarises the conclusions and recommendations from the meetings of the Fisheries Assessment Working Groups and the Fisheries Assessment Plenary held since last year's Plenary report was published. The meetings were convened to assess the fisheries managed within the Quota Management System, as well as other important fisheries in the New Zealand EEZ, and to discuss various matters that pertain to fisheries assessments.

In addition, summaries of environmental effects of fishing from research presented to the Aquatic Environment Working Group (AEWG) and the Biodiversity Advisory Group (BRAG) that have relevance to fisheries management have been incorporated for selected species. Paragraph 11 of the Terms of Reference for Fisheries Assessment Working Groups (FAWGs) includes "…information and advice on other management considerations (e.g., …by-catch issues, effects of fishing on habitat…)", and states that "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". In addition, the Terms of Reference for the AEWG (Paragraph 9) specifies the need "to review and revise existing environmental and ecosystem consideration sections of Fisheries Assessment Plenary report text based on new data or analyses, or other relevant information".

The report addresses, for each species, relevant aspects of the Fisheries Act 1996 and related considerations, as defined in the Terms of Reference for Fisheries Assessment Working Groups for 2020. In all cases, consideration has been based on and limited by the best available information. The purpose has been to provide objective, independent assessments of the current status of the fish stocks.

There are two types of catch limits used in this document – total allowable catch (TAC) and total allowable commercial catch (TACC). The current definition is that a TAC is a limit on the total removals from the stock, including those taken by the commercial, recreational and customary non-commercial sectors, illegal removals and all other mortality to a stock caused by fishing. A TACC is a limit on the catch taken by the commercial sector only. The definition of TAC was changed in the 1990 Fisheries Amendment Act when the term TACC was introduced. Before 1990, the term TAC applied only to commercial fishing. In the Landings and TAC tables in this report, the TAC figures equate to the TACC unless otherwise specified.

Only actual TACCs are provided. The actual TACCs are the values as of the last day of the fishing year; e.g., 30 September.

In considering customary non-commercial, and recreational interests, the focus has been on current interests and activities rather than historical activities. In most cases, there is little information available on the nature and extent of non-commercial interests, although estimates of recreational harvest are available in some instances. Information on illegal catches and other sources of mortality is provided where available.

Yield Benchmarks
The biological reference points, Maximum Constant Yield (*MCY*) and Current Annual Yield (*CAY*) first used in the 1988 assessment continue to be used in a small number of stock assessments. This approach is described in the section of this report titled "Guide to Biological Reference Points for Fisheries Assessment Meetings".

Sources of Data
A major source of information for these assessments is the fisheries statistics system. It is important to maintain and develop this system to provide adequate and timely data for stock assessments.

Other Information
For some assessments, draft Fisheries Assessment Reports that more fully describe the data and the analyses have been prepared in time for the Working Group or Plenary process. Once finalised, these documents are placed on the Fisheries New Zealand website in a searchable database.

Environmental Effects of Fishing
The scientific information to assess the environmental effects of fishing and enable this outcome comes primarily from research commissioned by Fisheries New Zealand and, for protected species only, the Department of Conservation (DOC). The work is reviewed by the Aquatic Environment Working Group (AEWG) (or a similar DOC technical working group) or by the Biodiversity Research Advisory Group (BRAG). Fisheries New Zealand has developed an "Aquatic Environment and Biodiversity Annual Review", which summarises the current state of knowledge on the environmental interactions between fisheries and the aquatic environment. The Aquatic Environment and Biodiversity Annual Review assesses the various known and potential effects of fishing on an issue-by-issue basis (e.g., the total impact of all bottom trawl and dredge fisheries on benthic habitat), whereas relatively brief fisheries-specific summaries have been progressively included in this report since 2005, starting with hoki. These fisheries-specific sections are reviewed by AEWG rather than by the FAWGs responsible for the stock assessment sections in each Working Group report.

Status of Stocks Summary Tables
Since 2009, the key information relevant to providing more comprehensive and meaningful information for fisheries managers, stakeholders and other interested parties has been summarised at the end of each chapter in a table format using the Guidelines for Status of the Stocks Summary Tables on pages 46–52. Beginning in 2012, Status of Stocks tables have incorporated a new science information quality ranking system, as specified in the Research and Science Information Standard for New Zealand Fisheries (2011). Beginning in 2013, Status of Stocks tables have incorporated explicit statements regarding the status of fisheries relative to overfishing thresholds.

Glossary of Common Technical Terms

Abundance Index: A quantitative measure of fish density or abundance, usually as a relative 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**).

ACE: Annual catch entitlement is the right to catch a certain amount of a fish stock during a fishing year.

AEWG: The Aquatic Environment (Science) Working Group.

Age frequency: The proportions of fish of different ages in the **stock,** or in the **catch** taken by either commercial fisheries 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 sample of fish.

Age-structured stock assessment: An assessment that uses a model to estimate how the numbers at age in the stock vary over time in order to determine the past and present **status** of a fish **stock**.

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

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.

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

AMP: ***Adaptive Management Programme***. This involves increased **TACCs** (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.**

ANTWG: Antarctic (Science) Working Group.

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

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).

B_o*: *Virgin biomass, unfished biomass. This is the theoretical **carrying capacity** of the **recruited** or **vulnerable** or **spawning 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**.

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

Bayesian stock assessment: 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** in the year of the assessment (usually a **mid-year biomass**).

Benthic: The ecological region at the lowest level of a body of water, including the sediment surface and some sub-surface layers

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, 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.**

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.

BRAG: Biodiversity Research Advisory Group.

B_{REF}**:** A reference average biomass usually treated as a management target.

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

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

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_0.

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. Also see ***MAY.

CELR: Catch Effort Landing Return.

CLR: Catch Landing Return.

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**.

Convergence: In reference to **MCMC** results from a **Bayesian stock assessment**, convergence means that the average and the variability of the parameter estimates are not changing as the **MCMC** chain gets longer.

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 a relative **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.

Density-dependence: Fish populations are thought to self-regulate: as population biomass increases, growth may slow down, mortality may increase, recruitment may decrease or maturity may occur later. Growth is density-dependent if it slows down as biomass increases.

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.

Discards: the portion of the catch thrown away at sea.

DWWG: The Deepwater (Science) Working Group.

ECER: Eel Catch-Effort Return.

ECLR: Eel Catch Landing Return.

Ecosystem: A biological community of interacting organisms and their physical environment.

EEZ: An **Exclusive Economic Zone** is a maritime zone beyond the **Territorial Sea** 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 state that arises when the **fishing mortality**, **exploitation pattern** and other fisheries or **stock** characteristics (growth, natural mortality, **recruitment**) do not change from year to year.

ERS: Electronic Reporting System

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

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

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

***F*:** The **fishing intensity** or **fishing mortality rate** is that part of the total mortality rate applying to a fish **stock** that is caused by fishing. Usually expressed as an instantaneous rate.

***$F_{0.1}$*:** 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 mortality rate** associated with a biomass of 40% B_0 at **equilibrium** or on average.

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

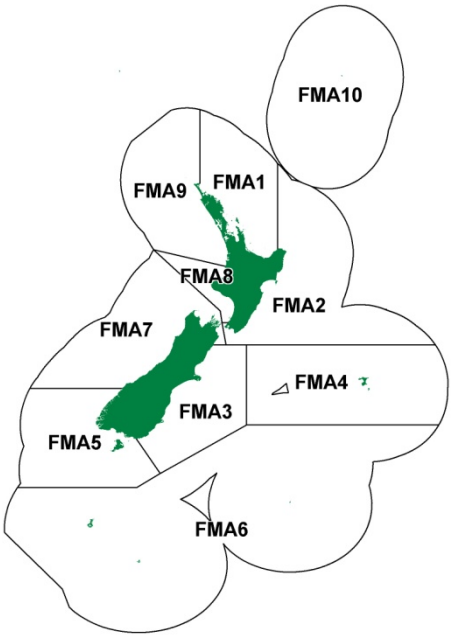
FAWGs: Fisheries Assessment (Science) Working Groups.

Fishing intensity: A general term that encompasses the related concepts of **fishing mortality** and **exploitation rate**.

Fishing mortality: That part of the total mortality rate applying to a fish **stock** that is caused by fishing. Usually expressed as an instantaneous rate.

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, 2015 is shorthand for 2014–15.

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



***F_{MAX}*:** 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 to the maximum (**sustainable**) economic yield.

F_{MSY}**:** 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}. Usually expressed as an instantaneous rate.

F_{REF}**:** The **fishing mortality** that is associated with an average biomass of B_{REF}.

FRML: Fisheries Related Mortality Limit.

Growth overfishing: Growth overfishing occurs when the **fishing mortality rate** is above F_{MAX}. This means that on average 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**.

HMS: Highly Migratory Species.

HMSWG: Highly Migratory Species (Science) Working Group.

Hyperdepletion: The situation where an abundance index, such as **CPUE**, decreases faster than the true abundance.

Hyperstability: The situation where an abundance index, such as **CPUE**, decreases more slowly than the true abundance.

Incidental capture: Refers to non-fish and protected species which were not targeted, but were caught.

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

LCER: Longline Catch-Effort Return.

Length frequency: The distribution of numbers at length from a sample of the **catch** taken by either commercial fisheries or research fishing. This is sometimes called a length composition.

Length-Structured Stock Assessment: An assessment that uses a model to estimate how the numbers at length in the stock vary over time in order to determine the past and present **status** of a fish **stock**.

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 (instantaneous) **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.

MAFWG: Marine Amateur Fisheries (Science) Working Group.

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 whereas the catch each year is the *CAY*. Also see ***CAY.

MCMC: Markov Chain Monte Carlo. See **Bayesian stock assessment**.

***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.

MIDWG: Middle-depths (Science) Working Group.

Mid-year biomass: The biomass after half the year's catch has been taken.

MLS: Minimum Legal Size. Fish above the MLS can be retained whereas those below it must be returned to the sea.

Model: A set of equations that represents the population dynamics of a fish stock.

Monte Carlo Simulation: 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 stock assessments**, parametric bootstraps and stochastic **projections**.

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

***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, and the current selectivity patterns exhibited by fisheries.

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

Natural mortality (rate): That part of the total mortality rate applying to a fish **stock** that is caused by predation and other natural events. Usually expressed as an instantaneous rate.

NCELR: Set Net Catch-Effort Landing Return.

NINSWG: Northern Inshore (Science) Working Group.

Objective function: An equation to be optimised (minimised or maximised) given certain constraints using non-linear programming techniques.

Otolith: One of the small bones or particles of calcareous substance in the internal ear of teleosts (bony fishes) that are used to determine their age.

Overexploitation: A situation where observed **exploitation** (or **fishing mortality**) rates are higher than **target levels**.

Overfishing: A situation where observed **fishing mortality** (or **exploitation**) rates are higher than **target** or **threshold** levels.

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

PCELR: Paua Catch-Effort Landing Return.

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 biological and fishing processes that result in changes in fish **stock** abundance over time.

Posterior: A mathematical description of the uncertainty in some quantity (e.g., **biomass**) estimated in a **Bayesian stock assessment**. This is generally depicted as a frequency distribution (often plotted along with the **prior** distribution to show how much the two diverge).

Potential Biological Removal (PBR): An estimate of the number of seabirds that may be killed without causing the population to decline below half the carrying capacity.

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 fisheries).

Prior: Available information (often in the form of expert opinion) regarding the potential range of values of a parameter in a **Bayesian stock assessment**. 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 fisheries 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 **TS** and **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 fisheries; 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.

RLWG: Rock Lobster (Science) Working Group.

SAMWG: Statistics, Assessments and Methods (Science) Working Group.

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

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

SFWG: The Shellfish (Science) Working Group.

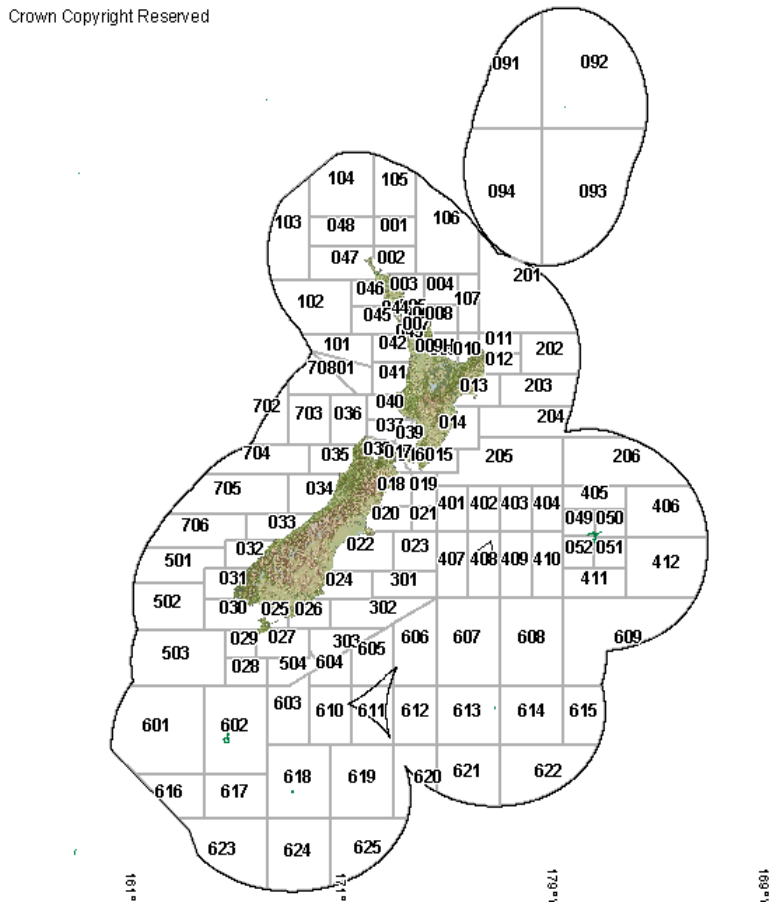
SINSWG: Southern Inshore (Science) Working Group.

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. 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 a 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 **Territorial Sea** and Exclusive Economic Zone (**EEZ**) statistical areas.



Steepness: A parameter of **stock-recruitment relationships** that determines how rapidly, or steeply, it rises from the origin, and therefore how resilient a stock is to rebounding from a depleted state. It equates to the proportion of virgin recruitment that corresponds to 20% B_0. A steepness value greater than about 0.9 is considered to be high, whereas one less than about 0.6 is considered to be low. The minimum value is 0.2.

Stock: The term has different meanings. Under the Fisheries Act, it is defined with reference to units for the purpose of fisheries management (Fishstock). 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 analysis of available data to determine stock status, usually through 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 management 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 asymptotic Beverton-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**. Stock status is often expressed relative to management benchmarks and **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 comprise 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 fisheries and **stock** attributes at a constant level simultaneously, thus sustainable fishing does not imply that the fisheries and the **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 sum of the Total Allowable Commercial Catch (**TACC**) and the allowances for customary Māori interests, recreational fisheries interests and other sources of fishing-related mortality that can be taken in a given period, usually a year.

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**, **fishing mortality** or **exploitation rate** 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** or **exploitation rate** 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: Trawl Catch Effort Processing Return.

TCER: Trawl Catch Effort Return.

TLCER: Tuna Longline Catch Effort Return.

TS: Territorial Sea. A belt of coastal waters extending at most 12 nautical miles (22.2 km; 13.8 mi) from the baseline (usually the mean low-water mark) of a coastal state.

U_{MSY}**:** The **exploitation rate** associated with the maximum sustainable yield.

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

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

$$L = L_\infty(1 - e^{-k(a-t_0)})$$

where L_∞ is the average length of the oldest fish, k is the average growth rate (Brody coefficient) and t_0 is a constant.

Vulnerable biomass: Refers to that portion of a **stock's biomass** that is available to fisheries. 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 Stock Assessment Working Groups in 2021

Overall purpose

The purpose of the Stock Assessment Working Groups is to assess the status of fish stocks managed within the Quota Management System, as well as other important species of interest to New Zealand. Based on scientific information the Stock Assessment Working Groups assess the current status of fish stocks or species relative to MSY-compatible reference points and other relevant indicators of stock status, conduct projections of stock size and status under alternative management scenarios, and review results from relevant research projects. They do not make management recommendations or decisions (this responsibility lies with Fisheries New Zealand fisheries managers and the Minister responsible for fisheries).

Preparatory tasks

1. Prior to the beginning of the main sessions of stock assessment meetings (January to May and July to November), Fisheries New Zealand fisheries scientists will produce a list of stocks and issues for which new stock assessments or evaluations are likely to become available prior to the next scheduled sustainability rounds. This list will include stocks for which the fishing industry and others intend to directly purchase scientific analyses. It is therefore incumbent on those purchasing research to inform the relevant Stock Assessment Working Group chair of their intentions at least three months prior to the start of the sustainability round. Stock Assessment Working Group Chairs will determine the final timetables and agendas for each Working Group.

2. At least six months prior to the main sessions of Stock Assessment Working Group meetings, Fisheries New Zealand fisheries managers will alert Fisheries New Zealand science managers and relevant Working Group chairs to unscheduled special cases for which assessments or evaluations are urgently needed.

Technical objectives

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

4. Where possible, to derive appropriate MSY-compatible reference points[1] 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. For stocks where the status is unknown, Stock Assessment Working Groups should use existing data and analyses to draw logical 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.

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[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: https://fs.fish.govt.nz/Page.aspx?pk=113&dk=16543

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

9. For fish stocks for which new stock assessments or analyses 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, Māori 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 in setting a TAC or TACC. Estimates of recreational harvest will normally be provided by the Marine Amateur Fisheries Working Group (MAFWG).

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 (AEWG) although the relevant Stock Assessment Working Group 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 complete, or review and update if necessary, the "Status of the Stocks" tables in the May and November Fisheries Assessment Plenary reports for all stocks under the purview of individual Stock Assessment Working Groups (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. It is desirable that full agreement amongst technical experts is achieved on the text of the Stock Assessment Working Group reports, particularly the "Status of the Stocks" sections, noting that the AEWG will review sections on bycatch and other environmental effects of fishing, and the MAFWG will provide text on recreational harvests. If full agreement amongst technical experts cannot be reached, the Chair will determine how this will be depicted in the Stock Assessment Working Group 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

15. To advise the Fisheries Assessment Plenary chair(s) 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 one or more base cases, or

(ii) the assessment is the first for a particular stock or the methodology has been substantially altered since the last assessment, or

(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

16. Stock Assessment Working Group members are bound by the Membership and Protocols required for all Science Working Group members (see separate document).

Terms of Reference for the Aquatic Environment Working Group (AEWG) in 2021

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 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 on benthic ecosystems, species, and habitat;
- effects on biodiversity, including genetic diversity; and
- changes to ecosystem structure and function from fishing, including trophic effects.

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 does not make management recommendations or decisions (this responsibility lies with Fisheries New Zealand fisheries managers and the Minister responsible for Fisheries).

Fisheries New Zealand 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 the functionality of the marine ecosystem and its productivity, whereas projects considered by AEWG more commonly focus on the direct effects of fishing.

Preparatory tasks

1. Prior to the beginning of AEWG meetings each year, Fisheries New Zealand fisheries scientists will produce a list of issues for which new assessments or evaluations are likely to become available that year.

2. The Ministry's research planning processes should identify most information needs well in advance but, if urgent issues arise, Fisheries New Zealand staff will alert the relevant AEWG Chair prior to the required meeting of items that could be added to the agenda. AEWG Chairs will determine the final timetables and agendas for meetings.

Technical objectives

3. To review any new research information on fisheries, 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. To review and revise existing environmental and ecosystem consideration sections of Fisheries Assessment Plenary report text based on new data or analyses, or other relevant information.

Working Group input to the Aquatic Environment and Biodiversity Annual Review

10. To include in contributions to the Aquatic Environment and Biodiversity Annual 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, bycatch 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 Fisheries New Zealand Principal Science Advisors and Aquatic Environment team manager about issues of particular importance that may require independent review or updating in the AEBAR. The general criterion for determining which issues should be discussed by a wider group or text changed 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.

Membership and Protocols for all Science Working Groups

15. The AEWG is bound by the same membership and protocols as are other Science Working Groups (see separate document).

Terms of Reference for the Biodiversity Research and Advisory Group (BRAG) in 2021

Overall purpose

Since 2000, the objectives of the Biodiversity Research Programme have been drawn directly from Fisheries New Zealand commitments to Theme 3 of the New Zealand Biodiversity Strategy (NZBS) 2000. Within this framework, the workstreams of the Biodiversity Research Programme have been adapted over time as new issues emerge, to build on synergies with other research programmes and work where biodiversity is under greatest threat from fishing or other anthropogenic activities, within the constraints of the overall purpose of the programme, which are:

> "To improve our understanding of New Zealand marine ecosystems in terms of species diversity, marine habitat diversity, and the processes that lead to healthy ecosystem functioning, and the role that biodiversity has for such key processes" and the NZBS definition of biodiversity (the variability among living organisms from all sources including inter alia, terrestrial, marine, and other aquatic ecosystems and the ecological complexes of which they are a part; this includes diversity within species, between species, and of ecosystem), the science currently commissioned broadly aims to:

- Describe and characterise the distribution and abundance of fauna and flora, as expressed through measures of biodiversity, and improving understanding about the drivers of the spatial and temporal patterns observed;

- Determine the functional role of different organisms or groups of organisms in marine ecosystems, and assess the role of marine biodiversity in mitigating the impacts of anthropogenic disturbance on healthy ecosystem functioning; and

- Identify which components of biodiversity must be protected to ensure the sustainability of a healthy marine ecosystem as well as to meet societal values on biodiversity.

Fisheries New Zealand also convenes an Aquatic Environment Working Group (AEWG) which has a similar review function to BRAG. 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.

BRAG may identify natural resource management issues that extend beyond fisheries management and make recommendations on priority areas of research that will inform Fisheries New Zealand or other government departments of emerging science results that require the attention of managers, policymakers, and decision-makers in the marine sector. BRAG does not make management recommendations or decisions (this responsibility lies with Fisheries New Zealand fisheries managers and the Minister responsible for Fisheries).

Preparatory tasks

1. Prior to the beginning of BRAG meetings each year, Fisheries New Zealand fisheries scientists will produce a list of issues for which new research projects are likely to be required in the forthcoming financial year. The BRAG Chair 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, Fisheries New Zealand fisheries managers will alert the Aquatic Environment and Biodiversity Science Manager and the Principal Advisor Fisheries Science at least three months prior to the required meetings where possible.

BRAG technical objectives

3. It is the responsibility of the BRAG to review, discuss, and convey views on the results of marine biodiversity research projects contracted by Fisheries New Zealand. The review process

is an evaluation of how existing research results can be built upon to address emerging research issues and needs. It is essentially an evaluation of "what we already know" and how this can be used to obtain "what we need to know". This information should be used by BRAG to identify gaps in our knowledge and for developing research plans to address these gaps.

4. It is the responsibility of BRAG participants to discuss, evaluate, make recommendations, and convey views on particular research area as required. Individual related projects on a species or fishery or research topic need to be aligned to relevant strategic and policy directions.

5. The recommendations on project proposals for the next financial year will be submitted via the Chair of BRAG to the Principal Science Advisor Fisheries.

6. The Biodiversity Research Programme includes research in New Zealand's TS, EEZ, Extended Continental Shelf, the South Pacific Region, and the Ross Sea region. There are six scientific work streams as follows:

    - To provide ecological information for a whole-of-systems approach to domestic fisheries management;
    - To develop tools and methods to assess and track the footprint of fisheries related activities on biodiversity and ecosystem functioning;
    - To identify and monitor threats and opportunities for adaptation or mitigation associated with environmental change;
    - To develop the blue-green economy within environmental constraints;
    - To evaluate and safeguard natural capital for future generations; and
    - To progress ecosystem-based fisheries management under international obligations.

BRAG input to the Fisheries Assessment Plenary and the Aquatic Environment and Biodiversity Annual Review

7. To contribute to and summarise progress on biodiversity research in the Aquatic Environment and Biodiversity Annual Review. This contribution is analogous to Working Group Reports from the Fisheries Assessment Working Groups.

8. To summarise the assessment methods and results, along with estimates of relevant standards, references points, or other metrics that may be relevant to biodiversity objectives, the Biodiversity Strategy, and international obligations.

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

10. To advise the Principal Science Advisor Fisheries about issues of particular importance that may require review by a Plenary meeting or summarising in the Aquatic Environment and Biodiversity Annual Review. The general criterion for determining which issues should be discussed by a wider group include:

    - Emerging issues, recent or current biodiversity status assessments, trends, or projections;
    - The development of a major trend in the marine environment that will impact on marine productivity or ecosystem resilience to stressors; and
    - Any new studies or data that impact on international obligations.

Membership and Protocols for all Science Working Groups

11. The BRAG is bound by the same membership and protocols as other Science Working Groups (see separate document).

Terms of Reference for the Marine Amateur Fisheries Working Group (MAFWG) in 2021

Overall purpose

The purpose of the MAFWG is to assess the harvest of marine amateur fishers from fish stocks managed within or outside the Quota Management System and to review other scientific or research information relevant to the management of marine amateur fisheries. MAFWG does not make management recommendations or decisions; this responsibility lies with Fisheries New Zealand fisheries managers and the Minister responsible for fisheries.

Preparatory tasks

1. It is anticipated that marine amateur fisheries research will focus primarily on the estimation of amateur harvests of fish stocks based on corroborated off-site national surveys conducted about every 5 years. At least six months before any such survey is conducted, Fisheries New Zealand fisheries managers will alert Fisheries New Zealand science managers and the Fisheries New Zealand Principal Science Advisors to their priority stocks for harvest estimation to facilitate good survey design. In years when national surveys are not being conducted, Fisheries New Zealand fisheries managers and fisheries scientists will work closely together to prioritise the meeting of other key information needs in relation to marine amateur fisheries.

Technical objectives

2. To review new research information on the harvest and harvesting patterns of marine amateur fishers using off-site and/or on-site methods, focussing primarily on priority non-commercial and shared stocks or fisheries identified by fisheries managers.

3. To develop methods for making reliable estimates of total catch by fish stock (finfish and shellfish); catch per unit of effort (CPUE); fish lengths and weights within the harvest; daily bag sizes in relation to limits; the spatial and temporal variability of fishing, CPUE, or harvest; and other information likely to inform fisheries management decisions, the development of environmental standards, or the formulation of relevant policy.

Working Group reports

4. In collaboration with relevant Stock Assessment Working Group Chairs, to provide timely and current information on marine amateur harvest for Working Group reports for non-commercial and shared stocks. MAFWG will also periodically review information on marine amateur harvest in Working Group reports to ensure accuracy and currency.

5. As necessary, provide information and advice on other management considerations for marine amateur fisheries (e.g. effects of fishing on habitat, other sources of mortality, and potential input controls such as bag limits, mesh sizes, and minimum legal sizes) required for specifying sustainability measures.

6. It is desirable that full agreement amongst technical experts is achieved on the information provided for Working Group reports on the harvest and other aspects of marine amateur fisheries. If full agreement amongst technical experts cannot be reached, the Chair will determine how this will be depicted in the Working Group report, will document the extent to which agreement or consensus was achieved, and record and attribute any residual disagreement in the meeting notes.

Membership and Protocols for all Science Working Groups

7. MAFWG members are bound by the Membership and Protocols required for all Science Working Group members (see separate document).

Terms of Reference for the Antarctic Working Group (ANTWG) in 2021

Overall purpose

The purpose of the ANTWG is to review science and research information intended for submission to or use by the Commission for the Conservation of Antarctic Marine Living Resources (CCAMLR). CCAMLR is an inter-governmental organisation that is committed to conserving the marine life of the Southern Ocean while allowing rational use of marine resources, including commercial fishing. The CCAMLR Convention requires that management considers the effects of fishing on dependent and associated species as well as on the target species. The area of jurisdiction of the CCAMLR Convention is approximately south of the circumpolar Antarctic Polar Front in the Southern Ocean. Science and research requested or used by CCAMLR may include, inter alia, fishery characterisations, abundance indices, catch-at-age or catch-at-length data, and stock assessment modelling to assess the status of fish stocks managed by CCAMLR; bycatch and unobserved mortality of protected species, fish, and other marine life; effects on biodiversity and benthic biodiversity, species, and habitat; and changes to ecosystem structure and function as a result of fishing, including trophic effects. The ANTWG also undertakes scientific review of documents and papers that may be submitted to the scientific working groups of CCAMLR to aid and inform its management. The ANTWG does not make management recommendations or decisions; these responsibilities lie with CCAMLR's Scientific Committee and the Commission.

Preparatory tasks

1. Prior to the first meeting of the ANTWG each year, the ANTWG Chair will produce a list of stocks/issues for which new stock assessments, evaluations, impact assessments, risk assessments, or other scientific analyses have been requested by the CCAMLR Scientific Committee or the Commission (including its contributing bodies), fishing industry, or other stakeholders. The ANTWG Chair will determine the final timetables and agendas of the working group each year, taking account of the available time and resources.

Technical objectives

2. To review new research information on stock structure, productivity, abundance and related topics for each fish stock or environmental issue under the purview of the ANTWG.

3. Where possible, to derive yields or reference points requested by CCAMLR's Scientific Committee or Commission related to fish stocks or environmental issues relevant to CCAMLR fisheries.

4. To conduct stock assessments or evaluations for selected stocks in order to determine the precautionary yields and status of the stocks relative to the requested reference points or, if no such reference points are specified by CCAMLR, MSY-compatible reference points and associated limits, based on the "Guide to Biological Reference Points for Fisheries Assessment Meetings" and New Zealand's Harvest Strategy Standard.

5. For stocks where the status is unknown, the ANTWG should, where possible, use any 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 are maintained, or if fishers or CCAMLR are considering modifying them in other ways.

6. Where requested by the CCAMLR Scientific Committee or Commission, to conduct projections of likely future stock status using alternative fishing mortality (or exploitation) rates or catches and other relevant management actions, based on input from the ANTWG and any guidance from the CCAMLR Scientific Committee or Commission.

7. Where requested by the CCAMLR Scientific Committee or Commission, in relation to specified stocks, to develop and report on alternative rebuilding scenarios.

8. To conduct environmental impact assessments and qualitative or quantitative risk assessments in relation to bycatch species, other species of concern, benthic systems, or vulnerable marine ecosystems to support the work of the CCAMLR Scientific Committee and Commission.

Working Group reports

9. To review, and update if necessary, the "Status of the Stocks" tables in the Fisheries Assessment Plenary report based on new data or analyses, or other relevant information.

10. To complete (and/or update) the Status of Stocks tables using the template provided in the Introductory chapter of the most recent May Plenary report.

11. To review, and update if necessary, the "Antarctic Science" chapter of the Aquatic Environment and Biodiversity Review (AEBAR) based on new data or analyses, or other relevant information.

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

Papers and reports to CCAMLR

13. Papers and reports summarising work reviewed by the ANTWG are generally submitted to CCAMLR's Scientific Committee, and their content varies widely. It is desirable that full agreement amongst technical experts is achieved on the content of such papers or reports, noting that deadlines for submission to CCAMLR may require the Chair to finalise text after a meeting of the ANTWG has considered and resolved scientific issues. If full agreement amongst technical experts cannot be reached, the Chair will determine how this will be depicted in the paper or report to be submitted to CCAMLR. In such cases, the Chair will also document the extent to which agreement or consensus was achieved and record and attribute any residual disagreement in the meeting notes.

Membership and Protocols for all Science Working Groups

14. ANTWG members are bound by the Membership and Protocols required for all Science Working Group members (see separate document).

Terms of Reference for the South Pacific Assessment Working Group (SPACWG) in 2021

Overall purpose

The purpose of the SPACWG is to review science and research information intended for submission to or use by the South Pacific Regional Fisheries Management Organisation (SPRFMO). SPRFMO is an inter-governmental organisation that is committed to the long-term conservation and sustainable use of the fishery resources of the South Pacific Ocean and, in so doing, safeguarding the marine ecosystems in which the resources occur. The SPRFMO Convention applies to the high seas of the South Pacific. Science and research information requested or used by SPRFMO may include, *inter alia*, fishery characterisations, abundance indices, catch-at-age or catch-at-length data, and stock assessment modelling to assess the status of fish stocks managed by SPRFMO. Also included will be characterisations, impact assessments, or risk assessments for the environmental effects of fisheries in the SPRFMO Area, particularly regarding vulnerable marine ecosystems (VMEs), and modelling work to assess the trade-offs inherent in, or likely outcomes of, potential management choices. SPACWG does not make management recommendations or decisions; these responsibilities lie with SPRFMO's Scientific Committee, Compliance and Technical Committee, and the Commission.

Preparatory tasks

1. Prior to the first meeting of SPACWG each year, the SPACWG Chair will produce a list of stocks/issues for which new stock assessments, evaluations, impact assessments, or risk assessments have been requested by the SPRFMO Commission (including its contributing bodies) or by fishing industry or other stakeholders. The SPACWG Chair will determine the final timetables and agendas of the working group each year, taking account of the available time and resources.

Technical objectives

2. To review new research information on stock structure, productivity, abundance and related topics for each fish stock or environmental issue under the purview of SPACWG.

3. Where possible, to derive reference points requested by SPRFMO's Scientific Committee or Commission related to fish stocks or environmental issues relevant to SPRFMO fisheries.

4. To conduct stock assessments or evaluations for selected stocks in order to determine the status of the stocks relative to the requested reference points or, if no such reference points are specified by SPRFMO, MSY-compatible reference points and associated limits, based on the "Guide to Biological Reference Points for Fisheries Assessment Meetings" and New Zealand's Harvest Strategy Standard.

5. For stocks where the status is unknown, SPACWG should, where possible, use any 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 are maintained, or if fishers or SPRFMO are considering modifying them in other ways.

6. Where requested by the SPRFMO Commission or Scientific Committee, to conduct projections of likely future stock status using alternative fishing mortality (or exploitation) rates or catches and other relevant management actions, based on input from the SPACWG and any guidance from the SPRFMO Scientific Committee or Commission.

7. Where requested by the SPRFMO Scientific Committee or Commission, in relation to specified stocks, to develop and report on alternative rebuilding scenarios.

8. To conduct environmental impact assessments and qualitative or quantitative risk assessments in relation to bycatch species, other species of concern, benthic systems, or vulnerable marine ecosystems to support the work of the SPRFMO Scientific Committee and Commission.

Papers and reports to SPRFMO

9. Papers and reports summarising work reviewed by SPACWG are generally submitted to SPRFMO's Scientific Committee, and their content varies widely. It is desirable that full agreement amongst technical experts is achieved on the content of such papers or reports, noting that deadlines for submission to SPRFMO may require the Chair to finalise text after a meeting of SPACWG has considered and resolved scientific issues. If full agreement amongst technical experts cannot be reached, the Chair will determine how this will be depicted in the paper or report to be submitted to SPRFMO. In such cases, the Chair will also document the extent to which agreement or consensus was achieved and record and attribute any residual disagreement in the meeting notes.

Membership and Protocols for all Science Working Groups

10. SPACWG members are bound by the Membership and Protocols required for all Science Working Group members (see separate document).

Terms of Reference for the Statistics, Assessments and Methods Working Group (SAMWG) in 2021

Overall purpose

The purpose of the SAMWG is to review and evaluate statistical methods, stock assessment methods, risk assessment methods, and any other quantitative or qualitative methods used in stock assessments, or research into the environmental effects of fishing, or assessments of marine biodiversity. The SAMWG will:

a) Develop a work programme each year to review and progress statistics, assessments and methods used by, or suitable for, Fisheries New Zealand purposes; and

b) Review quantitative and qualitative methods, particularly those that are novel, complex or contentious, referred by the Chairs of other Science Working Groups (SWGs).

The extent to which the SAMWG can fulfil these two purposes will be contingent on the availability of qualified quantitative staff and research providers to undertake and present the necessary analyses. On the basis of its reviews, the SAMWG will make recommendations, formulate guidelines, or suggest future research and provide these to other relevant SWGs or other entities. The SAMWG does not make management recommendations or decisions (this responsibility lies with Fisheries New Zealand fisheries managers and the Minister responsible for fisheries).

Preparatory tasks

1. Prior to the beginning of the financial year, Fisheries New Zealand fisheries scientists will produce a list of projects likely to be progressed in the coming year. This will be conducted in conjunction with the Chairs of other SWGs, and will be reviewed periodically with the Chairs throughout the year.

2. The list should also include relevant projects, including those already contracted or undertaken, and those anticipated by stakeholders directly purchasing scientific analyses. It is therefore incumbent on those purchasing research to inform the SAMWG Chair(s) of their intentions, preferably at least three months prior to the start of the financial year.

3. Some research purchased by Fisheries New Zealand fisheries managers may also benefit from review by the SAMWG. Fisheries New Zealand managers should be involved in producing the initial list of projects, and should alert Fisheries New Zealand science managers and the Fisheries New Zealand Principal Science Advisors to unscheduled special cases for which review or evaluation are urgently needed.

4. The SAMWG may have different Fisheries New Zealand Chairs for specific topic areas.

5. SAMWG Chair(s) will determine the final timetables and agendas for each Working Group.

Technical objectives

In conjunction with the Chairs of relevant SWGs and fisheries managers, the SAMWG will:

6. Review and evaluate new research information on statistical methods, stock assessment methods, risk assessment methods, and any other quantitative or qualitative methods used in stock assessments, or research into the environmental effects of fishing, or assessments of marine biodiversity, as specified in an annual research programme, or in ad hoc opportunities or requests throughout the year for such reviews, or as referred by the Chairs of other SWGs or fisheries managers.

7. Review and evaluate new methodologies for determining reference points for stock assessments and risk assessments.

8. Review and evaluate new methodologies for assessing the status of low information stocks or non-target species, or assessing risks to low information stocks or non-target species.

9. Review and evaluate new approaches to developing Management Procedures, Management Strategy Evaluations and Harvest Control Rules.

10. Review and evaluate new methods for assessing or mitigating the environmental effects of fishing.

11. Review and evaluate novel tools for accessing, querying, analysing and storing data to solve specific fisheries problems.

Reports produced

12. The SAMWG will make recommendations, formulate guidelines, or suggest future research and provide these to research providers, or to other relevant SWGs, or to other entities. These may be recorded in the records of SAMWG meetings, or written up more formally in Fisheries Research Reports (FARs) or Aquatic Environment and Biodiversity Reports (AEBRs).

13. In general, such recommendations, guidelines and future research considerations will be made in the form of a report outlining the rationale by which the SAMWG reached its conclusions. Where relevant, the research evaluated by the SAMWG may be published either as a FAR or an AEBR. Alternatively, the report of the SAMWG could be appended to a relevant FAR or AEBR, or provided to relevant entities as a separate, unpublished (but publicly available) short document.

14. It is desirable that full agreement amongst technical experts is achieved on the text of the documents to which the SAMWG contributes. If full agreement amongst technical experts cannot be reached, the Chair will determine how this will be depicted in the SAMWG minutes or other documents, 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 and AEBAR

15. The SAMWG will contribute appropriate text to the Plenary and AEBAR, as needed, in coordination with the Chairs of other SWGs.

Membership and Protocols for all Science Working Groups

16. SAMWG members are bound by the Membership and Protocols required for all Science Working Group members (see separate document).

Membership and Protocols for all Science Working Groups in 2021

This document summarises the protocols for membership and participation in all Science Working Groups including Stock Assessment Working Groups, the Aquaculture Working Group (AQWG), the Aquatic Environment Working Group (AEWG), the Biodiversity Research Advisory Group (BRAG), the Statistics, Assessments and Methods Working Group (SAMWG), the South Pacific Working Group (SPACWG), the Antarctic Working Group (ANTWG), and the Marine Amateur Fisheries Working Group (MAFWG).

Working Group chairs

1. Fisheries New Zealand will select and appoint the Chairs for Science Working Groups. The Chair will be a Fisheries New Zealand fisheries or marine 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[3] (the Research Standard), and that research and science information is reviewed by the relevant Working Group against the *P R I O R* principles for science information quality (page 6 in the Research Standard) and the criteria for peer review (pages 12–16 in the Research Standard);
    * requesting and documenting the names and affiliations of participants at each Working Group meeting and ensuring that these are noted in the Working Group meeting notes. Chairs are responsible for managing conflicts of interest (refer to page 15 of the Research Standard), and ensuring that fisheries management or aquaculture 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 or aquaculture decisions, the development of environmental standards, or the formulation of relevant fisheries policy 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 the Fisheries Assessment Plenary and the Aquatic Environment and Biodiversity Annual Review (AEBAR);
    * 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 Fisheries New Zealand Principal Science Advisors, relevant Fisheries New Zealand fisheries management or aquaculture staff, and other key stakeholders.

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

Working Group members

2. Membership of Science Working groups will be open to any participant with the agreement of the Working Group Chair, provided that they expect to meet a participation threshold that may vary depending on the Working Group in question. All members are expected to actively participate in at least two and preferably considerably more Working Group meetings during a given year.

3. Working Groups will consist of the following participants:

    * Fisheries New Zealand 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 the presented research to act in a peer review capacity;
    * representatives of relevant Fisheries New Zealand fisheries management or aquaculture teams; and
    * any interested party who meets the participation threshold and agrees to the standards of participation below.

4. Working Group participants must commit to:

    * participating appropriately in discussions;
    * 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.

5. 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.

6. Working Group participants must 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 participating in the review 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.

7. Participants in each Working Group will have access to the corresponding sections of the Science Working Group website including the Working Group papers and other information provided in those sections. Access to Science Working Group websites will generally be restricted to those who have a reasonable expectation of attending at least two meetings of a given Science Working Group each year.

8. Working Group members who do not adhere to the standards of participation (paragraph 4), or who use Working Group papers and related information inappropriately (see paragraph 10), 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, or permanently.

Working Group papers and related information

9. Working Group papers will be posted on the Fisheries New Zealand 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 some papers will be made available for the first time 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 following the meeting for additional comments from Working Group members.

10. Working Group papers are "works in progress" intended to facilitate the discussion of analyses by 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 not be cited.** Exceptions may be made in rare instances by obtaining permission in writing from an FNZ Principal Science Advisor or an FNZ Science Manager, 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.

11. From time to time, Fisheries New Zealand commissions external reviews of 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 Chair of the review. Under no circumstances should Working Group members approach reviewers directly until after the final report of the review has been published.

Working Group meetings

12. Meetings will take place as required, generally January–May and July–November for FAWGs and throughout the year for other Working Groups (AEWG, AQWG, BRAG, HMSWG, SPACWG, ANTWG and MAFWG).

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

14. 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 research reports, Working Group reports and AEBAR chapters;
* choice of best 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.

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

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

17. A record of recommendations, conclusions and action items will be posted on the Fisheries New Zealand website after each meeting has taken place.

18. Data upon which analyses presented to the Working Groups are based must be provided to Fisheries New Zealand in the appropriate format and level of detail in a timely manner (i.e. the data must be available and fully-accessible to Fisheries New Zealand; however, data confidentiality concerns mean that some data may not necessarily be made available to Working Group members).

19. Working Group processes will be evaluated periodically, with a view to identifying opportunities for improvement. Terms of Reference and the Membership and Protocols may be updated as part of this review.

20. Fisheries New Zealand scientists and science officers will provide administrative support to the Working Groups.

Information Quality Ranking

21. Science Working Groups are required to rank the quality of research and science information that is intended or likely to inform fisheries management or aquaculture 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 or aquaculture decisions, the development of environmental decisions, or the formulation of relevant policy 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 should 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

22. 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 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 stock, species or environmental issue under the purview of the Working Group, for use in subsequent research planning processes.

Fisheries Assessment Working Groups: Membership 2021

Antarctic Working Group

Convenors: Marine Pomarède and Nathan Walker

Members: Matthew Baird, Stephanie Brown, Jennifer Devine, Alistair Dunn, Jack Fenaughty, Greig Funnell, Simon Hoyle, Leyla Knittweis-Mifsud, Dan MacGibbon, Bradley Moore, Monique Messina, Phillip Neubauer, Richard O'Driscoll, Steve Parker, Matt Pinkerton, Brodie Plum, Darryn Shaw, Andy Smith, Perry Smith, Josh Van Lier, Tim Vaughan-Sanders, Barry Weeber, D'arcy Webber.

Species: Antarctic toothfish

Aquatic Environment Working Group

Convenors: Rich Ford, William Gibson, Marco Milardi, Ben Sharp, and Karen Tunley

Members: Ed Abraham, Carolyn Aguilar, Owen Anderson, Sonja Austin, Hilary Ayrton, Karen Baird, Barry Baker, Scott Baker, Joshua Baller, Josh Barclay, Steve Beatson, Erik Behrens, Elizabeth Bell, Mike Bell, Katrin Berkenbusch, Tiffany Bock, Laura Boren, Christine Bowden, David Bowden, Erin Breen, Paul Breen, Anthony Brett, Tom Brough, Curly Brown, Ian Brown, Sarah Bury, Glen Carbines, Susan Chalmers, Mark Chambers, Simon Childerhouse, Malcolm Clark, Tom Clark, Katie Clemens-Seely, Deanna Clement, George Clement, Damian Cloeter, Rochelle Constantine, Justin Cooke, Vonda Cummings, Roberta D'Archino, Steve Dawson, Igor Debski, Jessica Desmond, Jennifer Devine, Christopher Dick, Peter Dillingham, Clinton Duffy, Alistair Dunn, Matt Dunn, Charles Edwards, Mark Edwards, Pablo Esobar-Flores, Jack Fenaughty, Brit Finucci, David Foster, Allen Frazer, Debbie Freeman, Richa Garg, Sharleen Gargiulo, Shane Geange, Mark Geytenbeek, Dave Goad, Bruce Hartill, Barb Hayden, Jeremy Helson, Hannah Hendriks, Kristina Hillock, Freyda Hjorvarsdottir, Lyndsey Holland, Steven Holmes, Simon Hoyle, Lucy Jacob, Emma Jones, Daniel Kerrigan, Brianna King, Kirstie Knowles, Jo Lambie, Todd Landers, Kath Large, Laws Lawson, Mary Livingston, Carolyn Lundquist, Dave Lundquist, Greg Lydon, Darryl MacKenzie, Lucy Manning, Thomas Mattern, Sue Maturin, Gemma McGrath, Andy McKenzie, Stefan Meyer, Karen Middlemiss, David Middleton, Jodi Milne, Janice Molloy, Kiri Morgan, Mark Morrison, Rikki Mules, Philip Neubauer, Richard O'Driscoll, Enrique Pardo, Graham Parker, Steve Parker, Darren Parsons, Michael Patrick, Heiko Philippi, Johanna Pierre, Matt Pinkerton, Tiffany Plencner, Will Rayment, Trish Rea, Nathan Reid, Yvan Richard, Jesse Rihia, Peter Ritchie, Jim Roberts, Ashley Rowden, Richard Saunders, Carol Scott, Katherine Short, Liz Slooten, Andy Smith, Paul Starr, Kevin Sullivan, Darryl Sykes, John Taunton-Clark, Graeme Taylor, David Thompson, Finlay Thompson, Hamish Tijsen, Rob Tilney, Geoff Tingley, Rob Tinkler, Di Tracey, Ian Tuck, Dominic Vallieres, Anton Van Helden, Josh van Lier, Adam Watson, Shannon Weaver, D'Arcy Webber, Trudi Webster, Barry Weeber, Richard Wells, Tamar Wells, James Williams, Oliver Wilson, Inge Wisselink, Jeanne Wissing, Andrew Wright, Jingjing Zhang.

Biodiversity Research and Advisory Group (BRAG)

Convenor: Mary Livingston

Members: Teresa A'mar, Owen Anderson, Tara Anderson, Erik Behrens, Katrin Berkenbusch, Tiffany Bock, David Bowden, Paul Breen, Sarah Bury, Glen Carbines, Malcolm Clark, Tom Clark, George Clement, Damien Cloester, Vonda Cummings, Roberta D'Archino, Moira Decima, Matt Dunn, Pablo Escobar-Flores, Jack Fenaughty, Debbie Freeman, Jonathan Gardner, Sharleen Gargiulo, Shane Geange, William Gibson, Britt

Graham, Barb Hayden, Lyndsey Holland, Steven Holmes, Aaron Irving, Emma Jones, Daniel Kerrigan, Brianna King, Kirstie Knowles, Todd Landers, Cliff Law, Daniel Leduc, Carolyn Lundquist, Dave Lundquist, Greg Lydon, Alison MacDiarmid, Jeremy McKenzie, David Middleton, Marco Milardi, Te Taiawatea Moko-Mead, Wendy Nelson, Philip Neubauer, Richard O'Driscoll, Enrique Pardo, Darren Parsons, Michael Patrick, Rachael Peart, Matt Pinkerton, Nathan Reid, Jesse Rihia, Peter Ritchie, Jim Roberts, Karen Robinson, Ashely Rowden, Carol Scott, Andy Smith, Aroha Spinks, Kevin Sullivan, Phil Sutton, Rob Tilney, George Tingley, Di Tracey, Karen Tunley, Josh van Lier, Trudi Webster, Richard Wells, Tamar Wells, Oliver Wilson, Inge Wisselink, Jeanne Wissing.

Deepwater Working Group

Convenors: Gretchen Skea and Pamela Mace

Members: John Annala, Sira Ballara, Andrew Biggerstaff, Tiffany Bock, George Clement, Patrick Cordue, Jennifer Devine, Ian Doonan, Alistair Dunn, Matt Dunn, Pablo Escobar-Flores, Jack Fenaughty, David Foster, Charles Heaphy, Bruce Hartill, Steven Holmes, Simon Hoyle, Rosemary Hurst, Aaron Irving, Daniel Kerrigan, Marco Kienzle, Leyla Knittweis, Yoann Ladroit, Adam Langley, Kath Large, Greg Lydon, Dan MacGibbon, Vidette McGregor, Jeremy McKenzie, David Middleton, Sophie Mormede, Richard O'Driscoll, Jim Roberts, Tim Ryan, Richard Saunders, Andy Smith, Paul Starr, Benjamin Steele-Mortimer, Rob Tilney, Geoff Tingley, Rob Tinkler, Ian Tuck, Nathan Walker, D'Arcy Webber, Barry Weeber, Richard Wells.

Species:

Alfonsino	Ling
Arrow squid	Lookdown dory
Barracouta (BAR 4,5 & 7)	Orange roughy
Black cardinalfish	Redbait
Black oreo	Ribaldo (RIB 3 – 8)
Blue mackerel (EMA 3&7)	Rubyfish
Frostfish (FRO 3 – 9)	Scampi
Gemfish (SKI 3&7)	Sea perch (SPE 3 – 7)
Dark ghost shark (GSH 4 – 6)	Silver warehou
Pale ghost shark	Smooth oreo
Hake	Southern blue whiting
Hoki	Spiny dogfish (SPD 4&5)
Jack mackerel (JMA 3&7)	White warehou

Eel Working Group

Convenor: Marc Griffiths

Members: Kahu Aki, Dale Arbury, Mike Beentjes, Jacques Boubee, Anthony Charsley, Bill Chisholm, Shannan Crowe, Allen Frazer, Tom Hollings, Mike Holmes, Simon Howard, Simon Hoyle, Mark James, John Jameson, Nicole Kleven, Pamela Mace, Taniera Manaia, Michael Martin, Marco Milardi, Duncan Petrie, Taroi Rawiri, Alan Riwaka, Te Aomihia Walker, Dave West, Erica Williams, Leah Wyatt.

Species: Freshwater eels

Marine Amateur Fisheries Working Group

Convenors: Martin Cryer, Ian Tuck and Gretchen Skea

Members: Sonja Austin, Hilary Ayrton, Marty Bowers, Paul Breen, Glen Carbines, Tom Clark, Niki Davey, Mark Edwards, Mark Geytenbeek, William Gibson, Alistair Gray, Bruce Hartill, Sonja Hempel, Jake Hore, Andreas Heinemann, John Holdsworth, Peter van

Kampen, Graeme McGregor, Andy McKay, Alicia McKinnon, David Middleton, Jesse Rihia, Carol Scott, Paul Starr, Daryl Sykes, John Taunton-Clark, Scott Tindale, D'Arcy Webber, Oliver Wilson, Jeremy Wynne-Jones.

Northern and Southern Inshore Working Groups

Convenor: Marc Griffiths

Members: Teresa A'mar, John Annala, Cliff Baird, Mike Beentjes, Heather Benko, Anthony Brett, Alex Burton, Glen Carbines, Bill Chisholm, Denham Cook, Ian Doonan, Alistair Dunn, Matt Dunn, Pablo Escobar-Flores, Allen Frazer, Mark Geytenbeek, Bruce Hartill, Sonja Hempel, Tyla Hill-Moana, John Holdsworth, Rosie Hurst, Emma Jones, Briana King, Adam Langley, Laws Lawson, Pamela Mace, Dan MacGibbon, Jeremy McKenzie, Alicia McKinnon, David Middleton Jodi Milne, Phil Neubauer, Richard O'Driscoll, Darren Parsons, Keith Mawson, Nathan Reid, Richard Saunders, Carol Scott, Ali Schwaab, Hannah Stilborn, Paul Starr, Finlay Thompson, McKenzie Tornquist, Laura Tremblay-Boyer, Rodney Tribe, Ali Undorf-Lay, John Taunton-Clark, Nathan Walker, Cameron Walsh, Adam Watson, Tamara Wells, Oliver Wilson.

Species:

Anchovy	Groper	Ribaldo (RIB 1, 2 & 9)
Barracouta (BAR 1)	Jack mackerel (JMA 1)	Rough skate
Bluenose	John dory	School shark
Blue cod	Kahawai	Sea perch (SPE1,2,8,9)
Blue mackerel (EMA 1&2)	Kingfish	Smooth skate
	Leatherjacket	Snapper
Blue moki	Ling (LIN 1&2)	Spiny dogfish (SPD1,3,7,8)
Blue warehou	Parore	Sprats
Butterfish	Pilchard	Stargazer
Elephant fish	Porae	Tarakihi
Flatfish	Red cod	Trevally
Gemfish (SKI 1&2)	Red gurnard	Trumpeter
Garfish	Red snapper	Yellow-eyed mullet
Grey mullet	Rig	

Shellfish Working Group

Convenors: Marine Pomarède, Marco Milardi, Ian Tuck

Members: Owen Anderson, Michael Arbuckle, Cliff Baird, Mike Beentjes, Roger Belton, Katrin Berkenbusch, Des Boyce, Andrew Caddie, Bill Chisholm, Damian Cloeter, Hannah Charan-Dixon, Mike Connolly, Jeremy Cooper, Paul Creswell, Dayanitha Damodaran, Samik Datta, Jean Davis, Allen Frazer, Richa Garg, Mark Geytenbeek, Philip Heath, Sonja Hempel, Tyla Hill-Moana, Monique Holmes, Kath Large, Pamela Mace, Craig Marshall, Tom McCowan, Rebecca McLeod, Campbell McManaway, Keith Michael, Bryony Miller, Te Taiawatea Moko-Mead, Phil Neubauer, Fetuao Nokise, Tracey Osborne, Kura Paul Burke, Duncan Petrie, Richard Prosch, Trent Rasmussen, Jesse Rihia, Alice Sagar, David Skeek, Shade Smith, Storm Stanley, Paul Starr, Fred Te Miha, Gail Thompson, McKenzie Tornquist, Laura Tremblay-Boyer, Rodney Tribe, Karen Tunley, Oliver Wade, Nathan Walker, D'Arcy Webber, James Williams, Graeme Wright, Miao Zhang.

Species:	Cockles (COC 1A & 7A)	Horse mussel Kina	Sea cucumber
	Deepwater crab	King crab	Surf clam
	Dredge oysters (OYU 5, OYS 7 & 7C)	Knobbled whelk	Toheroa
		Large trough shell	Triangle shell
		Paddle crab	Trough shell
	Deepwater (king) clam (Geoduc)	Paua (PAU 2-7)	Tuatua
		Pipi (PPI 1A)	
	Deepwater tuatua	Prawn killer	
	Fine (Silky) dosinia	Queen scallop	
	Frilled venus shell	Red crab	
	Giant spider crab	Ringed dosinia	
	Green-lipped mussel	Scallop (SCA 1, CS & 7)	

South Pacific Working Group

Convenor: Marco Milardi

Members: Owen Anderson, Tiffany Bock, Tom Brough, Malcom Clark, Patrick Cordue, Duncan Currie, Igor Debski, Alistair Dunn, Matt Dunn, Jack Fenaughty, Shane Geange, Niels Hintzen, Peter Horn, James Larcombe, Dean Jurasovich, Carolyn Lundquist, Richard O'Driscoll, Steve Parker, Roland Pitcher, Brodie Plum, Ashley Rowden, Gretchen Skea, Andy Smith, Fabrice Stephenson, John Syslo, Karli Thomas, Geoff Tingley, Hamish Tijsen, Jan Geert Van Hiddink, Te Aomihia Walker, Cath Wallace, Barry Weeber.

Statistics, Assessments and Methods Working Group

Convenor: Pamela Mace

Members: Teresa A'mar, John Annala, Cliff Baird, Glen Carbines, Marc Chambers, Martin Cryer, Dayanitha Damodaran, Jennifer Devine, Ian Doonan, Alistair Dunn, Matt Dunn, Charlie Edwards, Rosa Edwards, Jack Fenaughty, Dave Foster, Allen Frazer, William Gibson, Marc Griffiths, Charles Heaphy, Sonja Hempel, Tyla Hill-Moana, John Holdsworth, Steven Holmes, Sunkita Howard, Simon Hoyle, Rosie Hurst, Greg Johansson, Emma Jones, Sophie Kincaid, Leyla Knitttweis, Brianna King, Adam Langley, Kath Large, Mary Livingston, Vidette McGregor, Andy McKenzie, Jeremy McKenzie, David Middleton, Marco Milardi, Russell Millar, Jodi Milne, Charli Mortimer, Marine Pomarède, Phil Neubauer, Richard O'Driscoll, Trent Rasmussen, Nathan Reed, Alice Sagar, Ali Schwaab, Carol Scott, Gretchen Skea, Paul Starr, John Taunton-Clark, Geoff Tingley, Rob Tinkler, McKenzie Tornquist, Ian Tuck, Nathan Walker, D'Arcy Webber, James Williams, Oliver Wilson, Dave Woods, Shijie Zhou.

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 fisheries 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 fisheries, reasons) so that to get the best yield from fisheries 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 fisheries.

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, 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 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***.

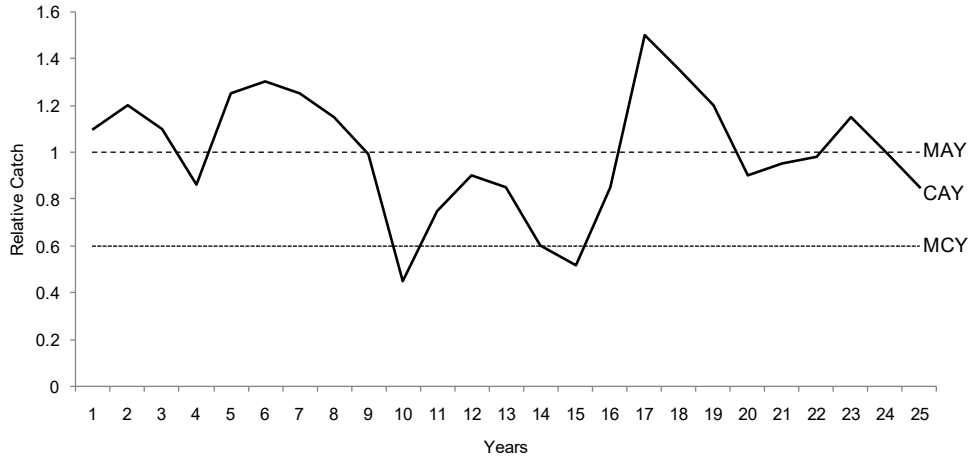

Figure 1: Relationship between *CAY*, *MCY* and *MAY*.

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) Māori 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 $F_{0.1}$, F_{MSY}, F_{MAX}, F_{MEY}, and ***M***.

The most common reference fishing mortality used in the calculation of ***CAY*** (and, in some cases, ***MCY***) is $F_{0.1}$ (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 ***F*** = 0. If an estimate of $F_{0.1}$ is not available an estimate of ***M*** may be substituted.

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.

F_{MSY}, the fishing mortality corresponding to the deterministic ***MSY***, is another appropriate reference point. 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 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	**Natural variability factor**
M	***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 fisheries are 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*** tonnes".

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 $\mathbf{0.5}MB_0$ (Gulland 1971). However various authors (including Beddington & Cooke 1983; Getz et al 1987; Mace 1988a) have shown that $\mathbf{0.5}MB_0$ 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 $F_{0.1}B_0$ may be somewhat higher or somewhat lower than **0.25**. This depends primarily on the steepness of the assumed stock recruitment relationship (*see* Mace & 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 historical estimates of biomass

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

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

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

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

$$MCY = {}^{2}/_{3}\, MSY$$

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

$$MCY = {}^{2}/_{3}\, CSP$$

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 ***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 fisheries 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 Fisheries New Zealand 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 B_{beg} is the projected stock biomass at the beginning of the fishing year for which the ***CAY*** is to be calculated and 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 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 (1984, 1991) 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 November 2014, there were a total of 292 stocks in this classification. The list of nominal stocks can be found at: https://www.fisheries.govt.nz/dmsdocument/19331-nz-nominal-fish-stocks-2018-report.

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). At the time, these changes were only applied for Status of Stocks tables updated in 2012. Subsequently, an attempt has been made to revise some of the older tables as well.

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	2019
Assessment Runs Presented	Base case model
Reference Points[4]	Target: 40% B_0 Soft Limit: 20% B_0 Hard Limit: 10% B_0 Overfishing threshold: $F_{40\%B0}$
Status in relation to Target[5,6]	B_{2019} was estimated to be 50% B_0; Very Likely (> 90%) to be at or above the target[6]
Status in relation to Limits[5,6]	B_{2019} is Very Unlikely (< 10%) to be below both the soft and hard limits[6]

Status in relation to Overfishing[6,7]	The fishing intensity in 2014 was Very Unlikely (< 10%) to be above the overfishing threshold [or, Overfishing is Very Unlikely (<10%) to be occurring][6]

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]	<insert relevant graphs, if available> 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 (2005–2017) is estimated to be near the long-term average.

Projections and Prognosis[12]	
Stock Projections or Prognosis	Biomass is expected to stay steady over the next 5 years assuming current (2016–17) 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: 2019	Next assessment: 2020
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	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 2012 assessment	

Major sources of Uncertainty[18]	- The base case model deals with the lack of older fish in commercial catches and surveys by estimating natural mortality at 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[19]
The impact of the current young age structure of the population on spawning success is unknown.

Environmental and Ecosystem Considerations[20]	
Observer coverage	Highly variable year to year (from 1.6 to 11.1%), but higher from 2008 onwards.
Non-target fish and invertebrate catch	Blue shark, lancetfish and porbeagle shark are the most commonly non-target fish species caught by the longline fleet (by number), but are rarely retained. Other species, like Rays bream and moonfish are caught more rarely, but are more frequently retained.
Incidental catch of seabirds	Observed capture rates of seabirds was highly variable prior to 2008 due to low levels of observer coverage. This fishery contributes primarily to the risk to Black petrel, Northern Buller's albatross and Gibson's albatross, among other species.
Incidental catch of cetaceans	Between 2002 and 2018, observers recorded one unidentified cetacean, two common dolphin, and one long finned pilot whale captured in this fishery. All of these cetaceans were released alive.
Incidental catch of pinnipeds	Between 2002 and 2018, there were two observed captures of New Zealand fur seals in this fishery. Both were released alive.
Incidental catch of other protected species	Between 2002 and 2018 incidental captures of 17 sea turtles were observed, these were leatherback turtles (10), unidentified turtles (5), green (1) and loggerhead (1) turtles.
Benthic interactions	There are no known benthic interactions for this fishery.

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 fisheries 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 fisheries status in relation to reference points.
    3 – Qualitative Evaluation: A fisheries characterisation with evaluation of fisheries 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 fisheries 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 processes that rank the quality of research and science information used in support of fisheries management decisions will be implemented. 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 Fisheries New Zealand'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.

Major sources of Uncertainty

18. The purpose of this section is to identify the most significant sources of uncertainty, or assumptions behind the contrasting sensitivity model runs presented.

Qualifying Comments

19. 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.

Environmental and Ecosystem Considerations

20. The "Environmental and Ecosystem Considerations" section should be used to summarise the observer coverage and list QMS bycatch species, non-QMS bycatch species and protected / endangered species and bycatch 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.

Fisheries New Zealand

Tini a Tangaroa

FNZ management teams and primary species managed

New Zealand Government

FISHERIES 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 (king) 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
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, PHC	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	SPR	All
Stargazer	STA	All
Surf clams (all species)	DAN, DSU, MMI, MDI, SAE, PDO, BYA	All
Tarakihi	TAR	All
Trevally	TRE	All
Trumpeter	TRU	All
Tuatua	TUA	All
Yelloweyed mullet	YEM	All

FISHERIES MANAGEMENT - DEEPWATER

Common name	Code	Stock
Alfonsino	BYX	All
Barracouta	BAR	BAR4, 5, 7
Cardinalfish	CDL	All
Deepwater crabs (red crab, king crab, giant spider crab)	CHC, KIC, 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, SOR, WOE, 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

FISHERIES MANAGEMENT - 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*

INTL POLICY - FISHERIES MGMT

Common name	RFMO
Antarctic toothfish, Patagonian toothfish	CCAMLR
Orange roughy	SPRFMO
Pacific HMS species *	WCPFC
Southern bluefin tuna	CCSBT

Regional Fisheries Management Organisations (RFMOs)

CCAMLR - *Commission for the Conservation of Antarctic Marine Living Resources*

SPRFMO - *South Pacific Regional Fisheries Management Organisation*

WCPFC - *Western and Central Pacific Fisheries Commission*

CCSBT - *Commission for the Conservation of Southern Bluefin Tuna*

** primarily ALB, BIG, SKJ, SWO and YFN*