Fisheries New Zealand
Tini a Tangaroa

Review of reference points (management targets and limits) for scallops

New Zealand Fisheries Assessment Report 2026/13

J.R. Williams,
M.J. Underwood.

ISSN 1179-5352 (online)
ISBN 978-1-997309-29-1 (online)

March 2026

Te Kāwanatanga o Aotearoa
New Zealand Government

Disclaimer

Enquiries should be directed to:

Fisheries Science Editor
Fisheries New Zealand
Ministry for Primary Industries
PO Box 2526
Wellington 6140
NEW ZEALAND

Email: Fisheries-Science.Editor@mpi.govt.nz
Telephone: 0800 00 83 33

This publication is also available on the Ministry for Primary Industries websites at:
http://www.mpi.govt.nz/news-and-resources/publications
http://fs.fish.govt.nz go to Document library/Research reports

Please cite this report as:
Williams, J.R.; Underwood, M.J. (2026). Review of reference points (management targets and limits) for scallops. *New Zealand Fisheries Assessment Report 2026/13.* 30 p.

TABLE OF CONTENTS

PLAIN LANGUAGE SUMMARY

In Aotearoa New Zealand, a reference point is defined as “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”. Reference points are fundamental for assessing stock status and guiding effective fisheries management.

A review of reference points (management targets and limits) for scallop fisheries was undertaken. This review: 1) evaluated reference points previously applied in New Zealand scallop fisheries; 2) examined international practices in scallop fisheries; and 3) outlined essential design considerations for effective reference points.

In New Zealand, yield-per-recruit (YPR) modelling has historically informed target fishing mortality rates for the Northland, Coromandel and Marlborough Sounds scallop fisheries. Recent assessments in Marlborough Sounds have shifted to an empirical approach, establishing substock-wide reference points based on a harvest or exploitation rate (U) target and absolute biomass soft and hard limits.

While some international fisheries have well-established biological reference points, others are still in the process of developing them.

While New Zealand’s approaches are broadly consistent with international practices significant refinement is possible. Developing spatially explicit reference points and integrating changing productivity and habitat considerations into the management framework would help ensure that New Zealand’s scallop fisheries are managed in line with best practice and remain resilient under dynamic ecological conditions.

The review informed a set of recommendations charting a pathway for developing improved reference points for New Zealand scallops and outlined short- and long-term research priorities. Collectively, they address key questions identified during the review: where management should occur, how effective spawning stock biomass (SSB) should be measured, how limits and targets should be set, how to adapt to change, how to monitor, and how to integrate these elements into effective management plans.

EXECUTIVE SUMMARY

Williams, J.R.[1]; Underwood, M.J.[1] (2026). Review of reference points (management targets and limits) for scallops.

***New Zealand Fisheries Assessment Report* 2026/13. 30 p.**

A review of reference points (management targets and limits) for scallop fisheries was undertaken in 2025. The review synthesised key insights into the development and application of reference points by: 1) evaluating reference points previously applied in New Zealand scallop fisheries; 2) reviewing international practices in scallop fisheries, highlighting both modelling and empirical approaches and their suitability across different management contexts; and 3) identifying key essential design considerations for scallop reference points, including spatial dynamics and scale, biological and ecological relevance, dynamic productivity, limits, targets and indicators, and analytical approaches.

In New Zealand, yield-per-recruit (YPR) modelling has historically informed target fishing mortality rates for the Northland, Coromandel and Marlborough Sounds scallop fisheries. Although modelling offers a structured theoretical approach, its utility is constrained by the complex and often oversimplified nature of scallop population and fishery dynamics. Recognising these limitations, recent assessments in Marlborough Sounds have shifted to an empirical approach, establishing substock-wide reference points based on a harvest or exploitation rate (U) target and absolute biomass soft and hard limits.

The reviewed scallop fisheries across Australia, Europe and North America represent a diversity of species, stock sizes, and management approaches, yet face common challenges such as sustainability concerns, pronounced spatio-temporal variability, and data limitations. While some fisheries have well-established biological reference points, others are still in the process of developing them. Most rely on maximum sustainable yield (MSY) frameworks, typically incorporating spawning stock biomass limits (SSB) and fishing mortality (F) targets.

Overall, New Zealand's approaches are broadly consistent with international practice. However, significant refinement is possible, particularly to address the inappropriate use of absolute biomass in yield calculations. Developing spatially explicit reference points and incorporating changing productivity and habitat considerations into the management framework would yield further improvements. These refinements would help ensure that New Zealand's scallop fisheries are managed in line with best practice and remain resilient under dynamic ecological conditions.

The review informed a set of recommendations charting a pathway for developing improved reference points for New Zealand scallops and outlined short- and long-term research priorities. Overall, the findings provide science-based advice to strengthen scallop assessment and management in New Zealand.

---

[1] Earth Sciences New Zealand.

1 INTRODUCTION

1.1 Overview

Reference points are fundamental for assessing stock status and guiding effective fisheries management (Cadrin 2024). Management targets and limits provide benchmarks to evaluate fishery performance and stock status, to prevent overfishing and ensure long-term sustainability. In practice, they function as performance measures, showing where a fishery stands relative to desired outcomes.

In Aotearoa New Zealand, a reference point is defined as "*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*" (Fisheries New Zealand 2024). Guidance on the development of reference points is outlined in the Harvest Strategy Standard (Ministry of Fisheries 2008, 2011), which sets out best-practice policy for defining fishery and stock targets and limits under the Quota Management System (QMS). For this overview, the following definitions and illustration (Figure 1) of reference points have been sourced from Fisheries New Zealand (https://www.mpi.govt.nz/fishing-aquaculture/fisheries-management/fish-stock-status/):

"Stocks are assessed against 4 performance measures:

- *A hard limit – a biomass level below which a stock is deemed to be collapsed and fishery closures should be considered to rebuild the stock at the fastest possible rate.*
- *A soft limit – a biomass level below which a stock is deemed to be overfished or depleted and needs to be actively rebuilt using a formal, time constrained rebuilding plan.*
- *A management target – the level of biomass or a fishing mortality rate that stocks are expected to fluctuate around for the best balance between use and sustainability, while allowing for environmental variation.*
- *Overfishing threshold – a rate of extraction (percentage of a stock removed each year) that should not be exceeded as it will ultimately lead to stock biomass falling below other performance measures."*

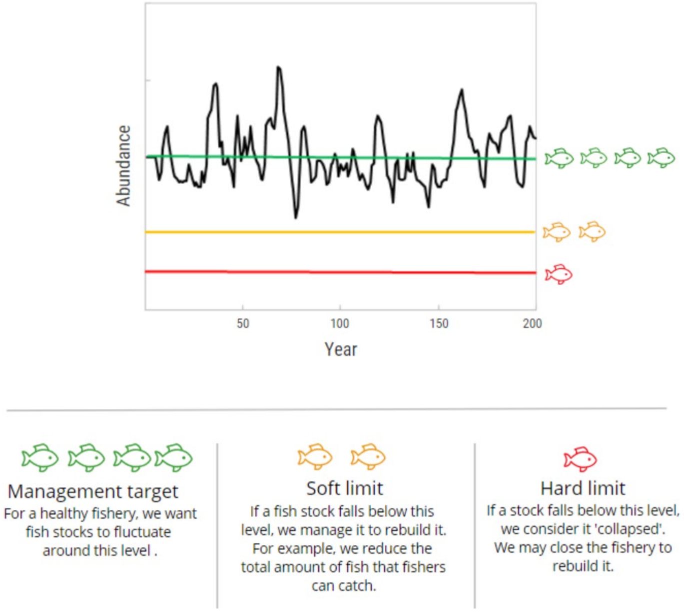

Figure 1: Diagram illustrating the relationship between the four performance measures. The trace of stock abundance (in black) is the result of fishing just below the overfishing threshold. Stock abundance fluctuates around the management target (in green) and sometimes approaches the soft limit (in yellow) but never goes below this level and stays far above the hard limit (in red). Management action to ensure the stock continues to fluctuate around the management target would normally be taken at all points where the stock dips too far below the target. Source: Fisheries New Zealand (https://www.mpi.govt.nz/fishing-aquaculture/fisheries-management/fish-stock-status/).

The purpose of this study was to review reference points for New Zealand scallops (*Pecten novaezelandiae*). New Zealand's once highly productive scallop fisheries have declined, leading to rāhui and closures of the main fishery areas in recent years (Fisheries New Zealand 2024). Surveys in 2021 and 2022 showed overall low abundance in the areas surveyed in both the North Island (Williams et al. 2024b, Williams et al. 2024c) and South Island (Williams et al. 2024a), and 2024 surveys in the North Island indicated only limited recovery in eastern Coromandel and Whangarei Harbour, with little improvement elsewhere (Williams et al. 2025). Productivity, influenced both by species biology and environmental conditions, appears to have shifted in certain regions, likely reflecting the combined effects of fishing pressure and environmental change (NIWA 2012, Hale et al. 2024, Williams et al. 2024d). Past management strategies have not halted these declines, highlighting the need for alternative approaches to secure long-term sustainability.

Scallops are benthic bivalves with limited mobility, dispersing mainly during the planktonic larval phase (Brand 2016). Their reproduction, growth, and survival vary widely, producing large natural fluctuations in abundance even without fishing. Recruitment variability drives pronounced changes in population size, making regular monitoring essential. Because scallops are sedentary, fishery-independent surveys provide reliable estimates of abundance and biomass, forming the basis for applying harvest strategies and setting sustainable catch limits (Orensanz et al. 2016).

At the core of scallop stock assessment are two fundamental questions:

1. How much can be sustainably harvested?
2. How much must remain in the water to ensure reproduction and future stock viability?

Reference points provide the answers, but they must be tailored to the biological, environmental, and management context of each fishery. This review addresses the overarching question: What reference points are appropriate for New Zealand scallops?

1.2 Objective

The overall objective of Fisheries New Zealand research project SCA2022-01 was to review the reference points (targets and limits) for scallops in the Marlborough Sounds (SCA 7 MS) and develop reference points for the other main scallop stocks: Northland (SCA 1), Coromandel (SCA CS), and Golden Bay / Tasman Bay (SCA 7 GBTB).

To achieve this, we conducted a desktop review of reference points previously applied in New Zealand's scallop fisheries and those used internationally. This work identified key design considerations, informed recommendations for developing improved, nationally consistent approaches, and outlined short- and long-term research priorities. Overall, the findings provide science-based advice to strengthen scallop assessment and management in New Zealand.

2 METHODS

We reviewed existing reference points for New Zealand scallops across the four key stocks/substocks (SCA CS and SCA 1 in the North Island, and SCA 7 MS and SCA 7 GBTB in the South Island). For each, we examined the studies underpinning reference point development and assessed what improvements are needed. In parallel, we conducted a review of international practices through systematic searches across multiple databases (Web of Science, Google Scholar, NIWA publications, and grey literature) using keyword combinations such as 'reference point', 'scallop' and 'Pecten'. Recognising that much fisheries research is reported in grey literature, we engaged directly with leading international scallop experts, including members of the International Council for Exploration of the Sea (ICES) Scallop Assessment Working Group (WGScallop) and participants in the International Pectinid Workshop. To capture emerging insights and current methodologies, we also developed and distributed an online survey targeting this expert community.

3 REVIEW OF NEW ZEALAND PRACTICES

Scallop fisheries assessment and management in New Zealand have relied on surveys to estimate biomass, with sustainable yield (Current Annual Yield, CAY) calculated directly from the survey results (Fisheries New Zealand 2024). The development of reference points for *P. novaezelandiae* has progressed since the 1990s, moving from yield-per-recruit (YPR) model-based approaches to empirical methods (Table 1). This section outlines key developments by fishery and then evaluates the strengths, limitations, and gaps of the previously applied approaches.

Table 1: New Zealand scallop reference points development timeline.

Stock/Year	Development comments	Reference points	References
SCA 7			
1992	SCA 7 introduced into the QMS.	Not reported	Fisheries New Zealand (2024)
1994	CAY first estimated for Marlborough Sounds section of the SCA 7 fishery	CAY using $F_{ref} = M$, M = 0.46 from Bull & Drummond (1994)	Drummond (1994)
1995	Simple YPR model constructed, but $F_{0.1}$ not reported	Not reported	Breen (1995)
1997	CAY estimated using high estimate of M (resulting in a very high estimated harvest rate of 53%).	CAY using $F_{ref} = M$, M = 0.75	Cranfield et al. (1997)
1998	CAY estimated using different M	CAY using $F_{ref} = M$, M = 0.46 or 0.75	Osborne (1998)
1999–2013	$F_{0.1}$ estimated using Breen (1995) YPR model, used as target for calculating CAY from 1999–2013.	CAY using $F_{0.1} = 0.553$ or 0.631, M = 0.40 or 0.50	Breen & Kendrick (1999)
2008–2010	SCA 7 survey analysis refined in 2008, CAY distribution and decision table approach implemented in 2009, and CAY estimated at different critical densities in 2010.	CAY using $F_{0.1}$, with refinements	Tuck & Brown (2008); Williams et al. (2009); Williams et al. (2010)
2011–2013	Concerns with estimates of $F_{0.1}$ and CAY raised. Review of the SCA 7 fishery.	CAY using $F_{0.1}$, with refinements, highlighting concerns	Williams & Michael (2011); Williams & Bian (2012); Williams et al. (2013a); Williams et al. (2014c)
2014–2015	Empirical approach applied.	CAY using U target, B hard & soft limits	Williams et al. (2014b); Williams et al. (2015)
2016	Review of New Zealand's scallop fishery stock assessment data and methods (April 2016). SCA 7 assessed at Fisheries Assessment Plenary (May 2016). SCA 7 fishery closure (July 2016).	U target, B hard & soft limits	Smith et al. (2016); Fisheries New Zealand (2024)
SCA CS & SCA 1			
1994	Empirical analysis of correlation between fishing pressure and subsequent population biomass and fishery landings in the Mercury beds to the north of Whitianga. Until 1997, northern assessments based on Provisional Yield (PY).	PY using lower bound of 95%CI for B (MLS = 100 mm)	Cryer (1994)
1997	SCA 1 introduced into the QMS. Individual-based YPR modelling conducted that considered direct effects of fishing (commercial dredging effects on adult scallop mortality, growth and condition).	CAY (direct effects): $F_{0.1}$ and $F_{40\%}$ targets; overfishing threshold = $F_{max;}$ M= 0.5	Cryer & Morrison (1997)
2002	SCA CS introduced to the QMS.	–	Fisheries New Zealand (2024)
2004	Individual-based YPR model revisited by considering direct and indirect effects of fishing.	CAY (direct & indirect effects) $F_{0.1}$ and $F_{40\%}$ targets; overfishing threshold = $F_{max;}$ M= 0.5	Cryer et al. (2004)
2005	Discussed previous work on reference points but no new analysis.	CAY using $F_{0.1}$	Cryer & Parkinson (2006)
2006–2012	CAY approach continued using $F_{0.1}$	CAY using $F_{0.1}$	Williams et al. (2013b)
2014	Review of discrepancy between CAY and landings in SCA CS.	CAY estimates not available (no surveys from 2013–2020)	Williams et al. (2014a)
2021–2022	Yield in 2021 from U targets instead of $F_{0.1}$. SCA 1 full and SCA CS partial closure in Dec 2021. SCA CS fishery full closure in Dec 2022.	U targets in the range 10–25%	Williams et al. (2024b); Fisheries New Zealand (2024)

3.1 SCA 7 Marlborough Sounds

In the Marlborough Sounds substock of the southern scallop fishery SCA 7, CAY was first estimated in 1994 by Drummond (1994) using a reference fishing mortality rate (F_{ref}), defined by the assumption that the target fishing mortality equalled natural mortality ($F = M$). Natural mortality was estimated at $M = 0.46$ (Bull & Drummond 1994), although subsequent assessments up to 1998 applied values ranging from 0.40 to 0.75. The higher estimate implied a surprisingly high harvest rate of 53%, highlighting the sensitivity of yield estimates to assumptions about M.

Breen (1995) constructed a simple YPR model for SCA 7 in 1995, although reference point estimates were not reported. This model was revisited in 1999 by Breen & Kendrick (1999) to estimate $F_{0.1}$, the level of fishing mortality at which the slope of the YPR curve is 0.1 times the slope at $F = 0$ (Fisheries New Zealand 2024). Depending on M (0.40–0.50), $F_{0.1}$ ranged from 0.553 to 0.631 (Breen & Kendrick 1999). From 1999–2013, $F_{0.1}$ became the standard target reference point for estimating CAY. In 2008, Tuck & Brown (2008) refined the SCA 7 survey analyses to align with those used in northern scallop fisheries. Subsequent further improvements were introduced, including the use of CAY distributions rather than point estimates and decision tables to represent uncertainty (Williams et al. 2009), and calculating CAY using biomass estimated at a range of critical density thresholds (Williams et al. 2010).

By 2011, issues with the CAY approach using $F_{0.1}$ as a target rate were raised (Williams & Michael 2011), and concerns were expanded on in later reports (Williams & Bian 2012, Williams et al. 2013a), in particular in a review of the SCA 7 fishery (Williams et al. 2014c).

This led to the development of an empirical approach that was first introduced in 2014 (Williams et al. 2014b) as an alternative to the YPR-based methods, marking a shift toward data-driven assessments. The empirical approach was applied again in 2015 (Williams et al. 2015) and endorsed by the Fisheries Assessment Plenary in May 2016 (Fisheries New Zealand 2024). The Plenary concluded that previous $F_{0.1}$ estimates were too high, leading to overestimated yields, especially because scallop fishing is spatially concentrated on a small proportion of the biomass. The agreed new approach was to calculate an empirical target harvest rate (U, denoting utilisation, also referred to as exploitation rate) based on a period when the biomass was stable or increasing, aiming to avoid harvest rates associated with biomass decline.

Despite these changes, low biomass led to closure of the SCA 7 fishery in July 2016 (Fisheries New Zealand 2024). Post-closure surveys continued to monitor stock status against the empirical U target and biomass (B) hard and soft limits. New research on SCA 7 ring-bag dredge efficiency in 2018 (Tuck et al. 2018) prompted recalculation of these values (Williams & Bian 2019), revealing sustainable catch levels were much lower than previously estimated. The empirical method initially set a target harvest rate of 0.22 (mean for 1999–2008 using historical dredge efficiency). Applying updated dredge efficiency estimates (Tuck et al. 2018) reduced this target to about 7% of absolute recruited biomass (Fisheries New Zealand 2024). Further analysis is needed to refine target harvest rates and biomass limits using effective spawning stock biomass rather than absolute biomass.

3.2 SCA 7 Golden Bay and Tasman Bay

No reference points have been developed for the Golden Bay and Tasman Bay areas of the SCA 7 fishery because it was managed as a rotational and enhanced fishery under s14 of the Fisheries Act 1996 (Fisheries New Zealand 2024).

3.3 SCA CS Coromandel and SCA 1 Northland

In the northern scallop fisheries SCA CS and SCA 1, yields were initially expressed as Provisional Yield (PY), later replaced by CAY in 1997 (Fisheries New Zealand 2024). This shift reflected a broader move toward standardised reference points across New Zealand scallop fisheries.

Early empirical work by Cryer (1994) examined the relationship between fishing pressure and subsequent absolute recruited biomass and fishery landings in the Mercury beds, north of Whitianga in SCA CS. The study concluded that fishing did not appear to have adverse effects on the population.

Cryer & Morrison (1997) advanced this work by examining YPR in northern commercial scallop fisheries. Using an individual-based population model and experimental estimates of incidental impacts on scallop growth and survival, they identified $F_{0.1}$ and $F_{40\%}$ as target reference points and F_{max} as an overfishing threshold. Their modelling considered only direct effects of commercial dredging on adult scallop mortality, growth, and condition.

Cryer et al. (2004) recalculated these estimates, incorporating indirect effects of fishing (Thrush et al. 1998), including juvenile mortality based on results from Talman et al. (2004). With increasing fishing effort, juvenile mortality increased, producing more dome-shaped YPR curves. This led to lower estimates of target fishing mortality rates and reduced predicted egg production, expressed as E_{Fmax} and $E_{F0.1}$ (percentages of unfished egg production). Cryer & Parkinson (2006) summarised the earlier work of Cryer & Morrison (1997) and Cryer et al. (2004) but did not conduct new analyses.

Williams et al. (2014a) reviewed discrepancies between CAY estimates and actual landings in SCA CS, highlighting concerns about the reliability of the existing CAY-based yield calculations. Acknowledging these concerns, additional to the 2021 survey report (Williams et al. 2024b), yield estimates in 2021 were calculated using target harvest rates rather than applying $F_{0.1}$ directly, reflecting a methodological shift in how sustainable yields were derived.

3.4 Insights from New Zealand practices

In 2016, an international panel reviewed New Zealand's scallop fishery stock assessment data and methods (Smith et al. 2016) and concluded that fishing mortality (F) or harvest rate (U) target reference points are more appropriate than biomass-based targets for scallops. This reflects the highly variable nature of scallop biomass, which makes biomass targets difficult to achieve consistently. The panel noted that setting fishing mortality levels is more viable: *"It remains possible to set biomass and fishing mortality reference points and, given the natural variability in the stock size of scallops, achieving chosen fishing mortality levels may be more feasible than meeting biomass targets (see Prager et al. 2003, Hart 2013 and associated literature)*" (Smith et al. 2016).

This perspective was later endorsed by the Statistics, Assessments and Methods Working Group (SAMWG) in 2021 (see the meeting minutes and presentations Williams 2021a, b) and at a joint United States–New Zealand meeting involving the University of Washington, NOAA fisheries, Fisheries New Zealand, NIWA (Williams 2022 presentation) and other researchers. Importantly, research also confirms that scallops are highly vulnerable to recruitment overfishing, reinforcing the need for limit reference points that protect minimum spawning biomass levels to avoid recruitment overfishing and reduce the risk of recruitment failure (Orensanz et al. 2016, Smith et al. 2016).

YPR modelling (Beverton & Holt 1957, Hart 2003, 2013) and related methods provide a framework for estimating fishing mortality targets. These models require inputs such as growth, natural mortality, length-weight relationships, size at maturity, fecundity, and fishing mortality (including incidental mortality). While simple YPR models can generate F-based targets, they fail to account for spatial heterogeneity in fishing mortality, growth, or natural mortality across the stock area. Deterministic YPR models are overly simplistic and may overestimate the F target (Smith & Rago 2004). More advanced, spatially integrated stochastic YPR models are therefore considered more realistic (Truesdell et al. 2016). Fishing mortality can also be expressed as an exploitation or harvest rate (U), which is particularly useful when data limitations prevent direct calculation of F.

Implementing F- or U-based strategies requires reliable pre-season biomass estimates to set annual catch limits. Surveys play a critical role in providing these estimates and monitoring stock status relative to targets and limits. However, it is important to use the appropriate biomass measure in these calculations. The target F or U should relate to the fished population: specifically, the estimated exploitable biomass of legal-sized scallops occurring at densities high enough to make fishing viable. This measure may differ from that used for a biomass limit, which needs to be more closely associated with effective spawning biomass. Effective spawning stock biomass can be defined as the biomass of mature scallops aggregated in densities conducive to successful spawning and fertilisation.

Historically, New Zealand scallop management relied on CAY calculations derived from $F_{0.1}$ and survey biomass. In practice, this approach failed, as fishers often could not achieve predicted yields. The issue was not necessarily with $F_{0.1}$ as a target, but with unrealistic values arising from violated assumptions. Uncertainties and key assumptions in CAY estimation were highlighted in previous SCA 7 survey reports (e.g., see Williams et al. 2013a), in a review of the SCA 7 fishery (Williams et al. 2014c), and in a review of discrepancies between CAY and catch in SCA CS (Williams et al. 2014a). These works concluded that using $F_{0.1}$ based CAY to estimate scallop yield was inappropriate. The main limitations of this approach were:

- **Overestimation of $F_{0.1}$.** Values of $F_{0.1}$ were unrealistically high, leading to overestimated yields. This reflected a narrow model scope for the SCA 7 YPR model, oversimplified deterministic assumptions, and sensitivity to biological parameters. For example, SCA 7 YPR modelling considered only direct fishing effects, excluding indirect impacts such as incidental mortality, reduced growth, and habitat degradation. Although the initial model tested 40% incidental mortality for sub-legal scallops, this was not incorporated into final estimates. Natural mortality (M) values for *Pecten novaezelandiae* may also have been set too high.
- **Poor representation of uncertainty.** CAY estimates are highly sensitive to uncertainty in $F_{0.1}$, however, point estimates were used instead of probability distributions.
- **Invalid stock dynamics assumptions.** Models treated the stock as a single dynamic pool with uniform distribution and fishing effort, but this assumption is often invalid (Caddy 1989, Orensanz & Jamieson 1998). In reality, scallops are patchily distributed, fishing is concentrated on dense beds, and seasons are short.
- **Incorrect biomass metric.** Absolute recruited biomass was used instead of exploitable biomass (i.e., biomass above fished critical density), leading to localised overfishing in dense beds and underfishing elsewhere. Applying the F target to absolute biomass produced catch limits misaligned with actual fishing patterns, which concentrated on high-density areas. Additionally, historical dredge efficiency was underestimated, inflating previous biomass and yield estimates.
- **Absence of limit reference points.** YPR modelling generated fishing mortality targets but did not identify limit reference points to protect against recruitment overfishing.

Recognising the limitations of YPR-based CAY estimation, scallop assessment in the Marlborough Sounds shifted to an empirical approach in 2015 (Williams et al. 2015, Fisheries New Zealand 2024). This approach aimed to address some of the shortcomings of model-based methods. However, the empirical approach developed also had weaknesses. It relied on absolute biomass rather than exploitable biomass. Using absolute biomass to estimate yield is now considered inappropriate because it assumes that exploitation is evenly distributed across the entire stock area. In reality, fishing pressure is concentrated on dense beds, where actual exploitation rates are much higher, while other areas experience little or no fishing. This mismatch leads to localised overfishing of productive beds, while other areas remain lightly fished. Further, evidence suggests that productivity in the Marlborough Sounds has changed substantially, raising questions about the current validity of harvest rate targets and biomass limits calculated on the basis of data from the 1990s and 2000s.

4 REVIEW OF INTERNATIONAL PRACTICES

Our literature review identified numerous relevant publications and reports including review articles and papers specifically on reference points in Australia, Europe, and North America for key scallop species selected as case study species for this study (Table 2). The literature review information was supplemented with recent research articles, unpublished reports and feedback from key researchers.

Some of the most recent and relevant reports and reviews include the proceedings of ICES workshops on reference points (WKREF1, WKREF2, WKNEWREF) (ICES 2022a, b, 2024b), the ICES WGScallop annual reports (e.g., see ICES 2024a, 2026), and reviews by Cadrin (2024) and Daleo (2024). Cadrin (2024) reviewed reference points for sedentary shellfish fisheries, showing that a range of reference points have been used globally and that the type of reference points is determined by the amount and type of data available for the fishery. Daleo (2024) reviewed biological reference points and harvest control rules in Marine Stewardship Council (MSC) certified fisheries for scallops and other sedentary species. The review found that typical biological reference point metrics represent either maximum allowable fishing pressure or minimum acceptable stock biomass and are determined using historical abundance data and life history parameters of the species. Sedentary species with pelagic larval dispersal, such as scallops, exhibit high temporal variability in recruitment and biomass, with no clear aggregate stock-recruit relationship (as expected, see Orensanz et al. 2016). This variability makes it challenging to determine reference points analytically using traditional methods like YPR. Among MSC-certified fisheries, there is considerable diversity in reference points (both analytical and empirical), estimation methods, and harvest control rules. The choice of reference points depends on management objectives, species' biological traits, and data availability and quality.

4.1 Pecten fumatus in Australia

The commercial scallop (*Pecten fumatus*) supports the Bass Strait Central Zone Scallop Fishery (BSCZSF), located between Victoria and Tasmania (Australian Fisheries Management Authority 2025a). This dredge fishery has a history of pronounced boom-and-bust cycles, with landings peaking at over 24 000 t green weight in 1983 (Blake et al. 2025). Since 2015, total allowable catch (TAC) limits have ranged between 2500 and 4000 t (Knuckey et al. 2022), although actual catches are often lower; in 2024, 10 vessels harvested 1015 t under a TAC of 3887 t (Australian Fisheries Management Authority 2025b). The fishery operates under the BSCZSF Management Plan and a harvest strategy revised since 2007 (Australian Fisheries Management Authority 2015), combining seasonal and spatial closures (input controls) with TAC limits (output controls). The fishery requirements are described in a BSCZSF Management Arrangements Booklet (Australian Fisheries Management Authority 2025a).

Because recruitment, growth, and mortality of *P. fumatus* are highly variable, conventional maximum sustainable yield (MSY) based reference points are not used. Instead, management applies an escapement-based harvest strategy to ensure that a minimum spawning biomass remains unfished, prioritising spawning biomass preservation over catch limits set based on total biomass estimates. At the start of each season, a 150 t TAC may be set to enable fishers to search for and locate commercially viable beds. The results of surveys then determine area closures and TAC limits under a two-tier system. Tier 1 is the more conservative option with 1000–2000 t TAC and closures of beds of high density with ≥ 1500 t biomass of large scallops (≥ 85 mm). Tier 2 allows for a TAC of ≥ 2000 t and closure of beds with ≥ 3000 t or more of large scallops (Australian Fisheries Management Authority 2015). The latter has been the target in recent years (Knuckey et al. 2022). These thresholds act as implicit limit reference points, essentially ensuring that protected biomass equals or exceeds that harvested. Industry also applies additional voluntary measures, including closures to protect juvenile scallops (Australian Fisheries Management Authority 2025a). Biomass at maximum economic yield (B_{MEY}) has been explored as a potential target reference point (Knuckey et al. 2022, Koopman & Knuckey 2024), but the fishery management strategy remains survey-driven and adaptive, reflecting the dynamic nature of scallop populations.

Table 2: Overview of scallop species with wild capture fisheries covered in this review.

Species	Countries	Main fishery regions/areas	Reference points	Year	Landings (t green$^{\#}$)	Reference
Aequipecten opercularis (Queen scallop)	Faroe Islands	Faroes (North Atlantic Ocean)	None	2023	5 306	ICES (2024a)
	Isle of Man (IoM)	Irish Sea (IoM 12 n. miles)	LPUE thresholds, swept area			
	UK, France	Celtic Seas, English Channel, Bay of Biscay	None			
Chlamys islandica (Iceland scallop)	Iceland	Iceland Sea (Breiðafjörður)	Length-based fishing pressure proxy	2024	60	Marine and Freshwater Research Institute (2025)
	Norway	Barents Sea (Svalbard)	$F_{MSY} = 0.25$, $F_{pgy} = 0.19$	2023	trial fishery	ICES (2024a)
Pecten fumatus (Commercial scallop)	Australia	Bass Strait Central Zone	B limits in closed areas	2024	1 015	Australian Fisheries Management Authority (2025b)
Pecten maximus (King scallop)	Europe combined	ICES combined total	–	2023	^74 494	ICES (2024a)
	France	English Channel	MSY, B_{MSY}, F_{MSY} (E & SW Channel, Bay of Seine)			
	England	English Channel, Celtic Sea, North Sea	MSY-proxy: $F_{35\%SPR}$ target (selected stocks)			
	Scotland	Atlantic Ocean, North Sea	$F_{0.1}$, B_{pa} (provisional reference points); LPUE thresholds (Shetland)			
	Isle of Man (IoM)	Irish Sea (IoM 12 n. miles)	LPUE thresholds, swept area			
	Wales, N. Ireland, Ireland, Spain	Irish Sea, Atlantic Ocean, Celtic Sea	None			
	Norway	Norwegian Sea (dive fishery)	None			

Species	Countries	Main fishery regions/areas	Reference points	Year	Landings (t green#)	Reference
Pecten novaezelandiae (New Zealand scallop)	New Zealand	Northland, Coromandel	$F_{0.1}$ target, limits not defined	2025	closed	Fisheries New Zealand (2024)
		Marlborough Sounds	U target, B soft and hard limits	2025	closed	Fisheries New Zealand (2024)
		Golden Bay, Tasman Bay	None	2025	closed	Fisheries New Zealand (2024)
Placopecten magellanicus (Atlantic sea scallop)	Canada	Georges Bank	B_{MSY} proxy, USR = 0.8 B_{MSY}, LSR = 0.3 B_{MSY}	2023	#5 186	DFO (2024c)
		Offshore Nova Scotia, Bay of Fundy				
	United States	Mid-Atlantic, Georges Bank	B_{MSY}, $B_{threshold}$ = 0.5 B_{MSY}, overfishing threshold = F_{MSY}	2023	#12 428	NOAA (2023)
		Gulf of Maine				
Ylistrum balloti (Saucer scallop)	Australia	Western Australia	Survey catch rate targets, thresholds, limits	2023	147	Chandrapavan & Jesson-Kerr (2023)

^ Predominantly from dredge fisheries, with minor landings from dive fisheries (e.g., in Norway: 359 t landings from dive fishery in 2023 (ICES 2024a)). Other alternatives to dredge gear are used in Western Australia (demersal trawl) and Norway (suction trial, Barents Sea).

Placopecten landings are in t meat weight (not green weight). Canada: 5186 t from Georges Bank 'a' &'b' combined; U.S. 12 428 t converted from the reported 27.4 million pounds of sea scallop meats (NOAA 2023).

4.2 *Pecten maximus* in Europe

The king scallop (*Pecten maximus*) supports major commercial fisheries in the northeast Atlantic, in the English Channel, Celtic Sea, Irish Sea, and North Sea. Total landings were 74 494 t green weight in 2023 (ICES 2024a). The fisheries are predominantly dredge fisheries, although small dive fisheries occur in some regions, such as in parts of Norway and Scotland.

The application of reference points for *P. maximus* in Europe varies markedly depending on data availability and management context. Cappell et al. (2018) reviewed the *Pecten maximus* fishery in the United Kingdom (UK), highlighting that, at that time, no stock status reference points were employed in any UK assessments. Since then, some regions have adopted MSY-based or proxy reference points, while others rely on trend-based indicators. For many scallop stocks, full analytical assessments are not yet feasible, although coordinated work is underway to develop models (ICES 2024a).

In France, certain areas such as the Eastern Channel and Bay of Seine use MSY-based reference points (F_{MSY}, B_{MSY}) derived from stock assessment models (CMSY++ and SPiCT), whereas other regions, including the Bay of Saint-Brieuc, lack formal reference points. An important aspect of French scallop dredge fisheries management is the aim to maintain multiple abundant age classes to buffer recruitment variability (ICES 2024a).

In the United Kingdom, a management plan for king scallops in English and Welsh waters has been developed (Department of Environment Food and Agriculture 2023). England has recently assessed selected stocks (Lawler & Nawri 2021, Lawler et al. 2022, 2023b, a) based on ICES advice to apply precautionary MSY approximations. The target reference point is fishing mortality (or harvest rate) that achieves 35% of virgin spawning potential ($F_{35\%SPR}$), a commonly used reference point within ICES advisory areas (ICES 2022a). Scotland has defined provisional precautionary reference points based on the outputs of stock assessments: $F_{0.1}$ derived from YPR analysis, and B_{pa} derived from the lowest stock biomass. The 2023 stock assessment report (Dobby et al. 2025) is the latest available report, but Scottish scallop stock assessments were recently updated, as reported at the 2025 ICES WGScallop meeting (ICES 2026). In Shetland, landings per unit effort (LPUE) reference points are used, with the target defined as 80% of mean LPUE (2008–2015), and the limit at the minimum observed LPUE (in 2001). Ireland, Northern Ireland and Wales lack formal reference points but have initiated work on stock assessment model development.

Isle of Man does not use formal MSY-based reference points, although work is underway on stock assessment modelling. Current management applies LPUE (catch rate) thresholds and swept-area (representing fishing intensity) operational indicators (ICES 2024a). A long-term management plan for king scallop fishery resources within the territorial sea has been developed to address resource and management challenges (Department of Environment Food and Agriculture 2022). A suite of measures are used including effort controls, daily catch limits, annual TACs, and an extensive network of permanent and temporary spatial closures (Bloor 2021, Bloor et al. 2021, Bloor et al. 2024, Department of Environment Food and Agriculture 2024, 2025).

Norway does not apply reference points to its *P. maximus* dive fishery, instead relying on practical input controls shaped by its development as a diver-based fishery in the 1960s after dredging proved unworkable on rough grounds with abundant seaweed that filled the dredges (Wiborg & Bøhle 1974, Strand & Vølstad 1997, Strand & Parsons 2006, Strand et al. 2016, ICES 2024a). As participation increased in the 1990s and concerns about over-exploitation grew, authorities introduced commercial-diver certification requirements and later a 100 mm minimum landing size, while proposals for closed areas were rejected due to enforcement costs and confidence in divers' rotational harvesting practices. Stock monitoring by the Institute of Marine Research (IMR) since the mid-1990s in the main harvest area in Mid-Norway shows year classes 1–8 consistently present, indicating stability despite variation in dominant cohorts. The fishery is considered sustainable under this approach, though stricter safety regulations have slowed its development and emerging harvesting technologies may introduce new sustainability challenges.

Spain does not have formal biological reference points for *P. maximus*, and this reflects both the small scale of the Galician scallop fisheries and the limited data available to support analytical assessments; management instead relies on seasonal closures, licensing, and daily catch limits (Duncan et al. 2016; L. Pérez-Parallé, pers. comm.).

Overall, *P. maximus* management across Europe is primarily effort-based, supported by technical measures. Licensing and effort controls are common in the UK and Ireland. Minimum landing sizes (typically 100–110 mm) vary by region. Spatial and temporal closures are widely used to protect spawning aggregations and juvenile scallops. Catch limits, including TACs and weekly catch limits, apply in some areas, such as the Isle of Man. Where analytical assessments are not feasible, survey trends in biomass and recruitment are used to guide management decisions.

4.3 *Placopecten magellanicus* in the United States

The Atlantic sea scallop (*Placopecten magellanicus*) supports the world's largest wild scallop fisheries, extending from Cape Hatteras (North Carolina) to Newfoundland in the Northwest Atlantic. The U.S. dredge fishery for sea scallops is managed by NOAA Fisheries and the New England Fishery Management Council under the Atlantic Sea Scallop Fishery Management Plan (NOAA 2023). Since 2010, over 500 vessels have participated in the fishery. The stock is monitored using dredge gear and increasingly advanced survey technologies, including drop cameras and the towed HabCam system (Northeast Fisheries Science Center 2018). Management measures include long-term closed areas, rotational openings, gear restrictions, and effort controls.

Stock assessments have progressed from dredge-based biomass estimates, since 1975, to forward-projecting size-structured models introduced in 2007. The current sophisticated assessments incorporate recruitment, spawner-recruit relationships, spawning biomass, gear selectivity, and uncertainty in key parameters.

The U.S. scallop fishery is notable for its well-established biological reference points, derived using a stochastic yield model (SYM) (Hart 2013), which explicitly accounts for uncertainty in natural mortality and stock-recruit relationships when estimating MSY-based reference points. The reference points include: $B_{target} = B_{MSY}$; $B_{threshold} = 0.5\ B_{MSY}$; overfishing threshold = F_{MSY}; and MSY.

The last full benchmark assessment was in 2018 (Northeast Fisheries Science Center 2018), when B_{MSY} was estimated at 116 766 t of meats (adductor muscle), $B_{THRESHOLD}$ was set at half B_{MSY} (58 383 t), and F_{MSY} was 0.64, an increase from 0.48 in 2014 due to revised mortality estimates. MSY was estimated at 46 531 t. The 2018 assessment recommended further development of spawning stock biomass (SSB) as a reference metric, noting that using spawning stock biomass instead of total biomass made 'strong sense biologically'. SSB was used in the 2020 assessment (Northeast Fisheries Science Center 2020). Concerns were raised about using a fishing mortality calculated across all areas, which can result in underestimating the fishing mortality within the main fishing grounds. Hart (2003) suggested that the use of an overall fishing mortality could lead to fishing grounds being depleted unknowingly, even if the overall fishing mortality shows no overfishing.

The most recent peer-reviewed Research Track assessment for U.S. Atlantic sea scallops was in April 2025 (NOAA Fisheries 2025), which reaffirmed the use of SYM-derived reference points but highlighted the risks of applying a single set of reference points across the combined regions of Mid-Atlantic and Georges Bank. Spatial heterogeneity in scallop dynamics means combined-area reference points risk masking localised overfishing, particularly on Georges Bank, which holds most of the biomass and fishing activity (Table 3). The Mid-Atlantic stochastic yield curve was notably flat, indicating that F_{MSY} is poorly defined for this region, likely influenced by recent increases in natural mortality and changing ocean conditions; in contrast, the Georges Bank yield curve showed a clear peak and well-defined F_{MSY} (NOAA Fisheries 2025). The Review Panel recommended managing at finer spatial scales to avoid depletion of individual grounds (NOAA Fisheries 2025).

Table 3: Select biological reference points for U.S. Atlantic sea scallop derived from the SAMS (Scallop Area Management Simulator) model developed for the 2025 Atlantic Sea Scallop Research Track Assessment. Reproduced (with row added to describe reference points) from NOAA Fisheries (2025). Values of MSY and B are in metric tons (mt) of meats.

	Maximum sustainable yield	Overfishing threshold	Biomass target	Biomass threshold	Biomass 2023	Fishing mortality 2023
Region	MSY	F_{MSY}	B_{MSY}	$B_{THRESHOLD}$	B_{2023}	F_{2023}
Mid-Atlantic	7 941	1.56	15 909	–	20 556	0.06
Georges Bank	22 706	0.36	83 414	–	49 400	0.47
Combined	28 402	0.49	93 282	41 707	69 956	0.33

Management of the Atlantic sea scallop fishery integrates biological reference points for setting catch limits with rotational and permanent closed areas to protect spawning aggregations and rebuild biomass. Effort controls and gear restrictions help to reduce habitat impacts, while quota-based management operates under the Fishery Management Plan. Monitoring combines dredge surveys with advanced technologies (drop cameras and HabCam) to generate high-resolution spatial data.

Assessments use a suite of size-structured models, each serving a distinct purpose: SYM estimates reference points; CASA (Catch-at-Size Analysis) estimates abundance, biomass, fishing mortality, recruitment, and related metrics for past fishing years; and SAMS (Scallop Area Management Simulator) is a forecasting model that operates at finer spatial scales than the other two models, which allows it to simulate area management such as rotational and long-term closures.

Key challenges include managing spatial heterogeneity that complicates the application of combined reference points, refining SSB-based reference metrics, and balancing rotational closures with economic efficiency and stock rebuilding.

4.4 *Placopecten magellanicus* in Canada

Canada assesses and manages Atlantic sea scallops (*Placopecten magellanicus*) across the two major fishery areas of offshore Nova Scotia (including Georges Bank, German Bank, Browns North, Eastern Scotian Shelf, Banquereau, St. Pierre Bank) and inshore Nova Scotia (Bay of Fundy and inshore areas), plus in the Gulf of St. Lawrence and Quebec coastal waters. Management and assessment responsibilities are divided between Fisheries and Oceans Canada (DFO) regions, and Scallop Fishing Area (SFA), reflecting the resource's spatial complexity (Coughlan 2023, DFO 2023, 2024a, b, c). Some areas apply reference points, while others have proposed but not adopted them. Surveys rely mainly on dredge-based biomass estimates, similar to U.S. practice, though management approaches vary regionally.

Canada uses a mix of biomass-based reference points and effort-based triggers, with the SFAs with the largest fisheries generally applying MSY-based limits and others relying on CPUE thresholds and survey biomass indices. For the largest fishing area (Georges Bank 'a'), a stock assessment framework was introduced in 2009 (Jonsen et al. 2009) and accepted by peer-review in 2013 (Hubley et al. 2014), and this framework is used to provide annual updates. A key innovation was incorporating spatial variation in productivity and fishing effort when setting biological reference points (Smith et al. 2017), but this approach has recently become unsuitable as it could not accommodate the substantial productivity shifts observed in recent years. In response, new spatially explicit models are being developed, and one of these has recently been applied to establish reference points for Browns Bank (McDonald et al. 2023, Keith et al. 2025b, a).

The reference points for the Georges Bank ‘a’ stock illustrate the general framework that has been used for MSY-based reference points in Canada: an upper stock reference point (USR = 0.8 B_{MSY}, defining the boundary of the healthy zone below which removals are reduced), a limit reference point (LSR = 0.3 B_{MSY}, representing a recruitment over-fishing threshold below which fishing is expected to cause serious harm), and a removal reference point (E_{MSY} = 0.25, a maximum exploitation rate or harvest rate) (DFO 2024c) (Smith & Hubley 2012). In practice, B_{MSY} has functioned as a proxy rather than an explicitly estimated MSY benchmark, because it has been based on long-term mean biomass from a historical period rather than on simulations of MSY dynamics. These reference points are derived from long-term biomass averages and updated annually as new data are incorporated (Hubley et al. 2014). Reference point values may differ among stocks (e.g., LSR is often set at 0.4 B_{MSY}, and lower values of E_{MSY} may be needed), depending on stock productivity and management context. Although Canada has recently begun estimating B_{MSY} directly for some offshore stocks (e.g., Browns Bank and Sable Bank) (Keith et al. 2025b, a), this approach has not yet been adopted for Georges Bank or for inshore stocks, so the framework described here remains the basis for most major stocks at present.

In the Gulf of St. Lawrence (DFO 2024a, Harbicht et al. 2024), temporary closures have also been used as a management tool. For example, SFA 22 was closed for five years at industry request, and in SFA 21A, if CPUE falls below 0.5 kg/h·m (kilograms of meat per hour per metre of dredge width), a three-year closure is triggered (Niles et al. 2021). In Quebec coastal waters, no formal biomass reference points are applied; management relies on CPUE limits and area closures, although reference points have been proposed but not adopted (DFO 2023). In Quebec, the scallop fishery is mixed, targeting both Atlantic sea scallops and Icelandic scallops (*Chlamys islandica*). In SFA 20A, where Atlantic sea scallops dominate, management uses catch-per-unit-effort (CPUE) limits: a soft limit of 1.5 kg/h·m and a hard limit of 0.85 kg/h·m. Spatial closures are also applied, such as the permanent closure of SFA 20E as a scallop refuge (DFO 2023).

Canada’s scallop management integrates biomass-based reference points in offshore areas with effort-based CPUE thresholds in Quebec coastal fisheries. Spatial management includes permanent and temporary closures to protect spawning aggregations and rebuild stocks, while adaptive measures allow closures to be triggered by CPUE declines or industry requests. Quota and effort controls, including TACs and seasonal restrictions, are applied in some regions. This multi-tiered approach reflects regional differences in stock dynamics and fishery structure. Offshore areas such as Georges Bank align closely with U.S. MSY-based strategies, while inshore fisheries rely more on operational indicators like CPUE.

4.5 *Ylistrum balloti* in Australia

The saucer scallop, *Ylistrum balloti* (formerly *Amusium balloti*) supports important demersal trawl fisheries in Western Australia, particularly around the Abrolhos Islands (Kangas et al. 2021). This fishery has experienced significant variability in stock abundance, including severe declines following marine heatwaves, which prompted adaptive management responses and highlighted the importance of pre-season monitoring (Kangas et al. 2022). The management objective is to maintain spawning stock biomass at levels where environmental factors, rather than fishing pressure, primarily influence recruitment. This approach is underpinned by research that determined a stock-recruitment-environment relationship (SRER) for each of the scallop stocks based on fishery-independent survey indices (Caputi et al. 2021). This study provided the key insights for establishing the limit reference point, the threshold at which recruitment becomes impaired, in the harvest strategies for each stock (Kangas et al. 2022).

Key biological reference points include a target reference point representing the desired spawning biomass level to achieve sustainable recruitment, a threshold reference point serving as an early warning signal that triggers review and potential management action, and a limit reference point indicating recruitment impairment and prompting strong management intervention, including closures. These reference points are assessed twice annually: the November survey determines the target, threshold, and limit reference points for the upcoming season, while the February survey updates threshold and limit values to account for environmental variability.

The harvest strategy has clear performance indicators (scallop indices), reference levels (survey density-based targets, thresholds and limits) and associated harvest control rules to achieve sustainability objectives (Western Australia. Dept. of Fisheries. 2015, Department of Fisheries 2020). Management actions are linked to the status of spawning biomass relative to reference points. Fishing proceeds normally when biomass is above the target, increased monitoring and potential effort reductions occur when biomass falls between the target and threshold, and immediate closures and recovery measures are implemented when biomass falls below the limit. This adaptive approach is supported by pre-season surveys using fishery-independent methods and dynamic harvest control rules that respond to environmental drivers and stock status.

The Western Australian *Y. balloti* fishery approach demonstrates how density-based reference points and environment-linked harvest strategies can maintain resilience in fisheries subject to climate variability. The integration of SRER into reference point setting provides a biologically robust basis for management, and the approach emphasises timely responses to extreme events, which may become more frequent under climate change.

4.6 *Aequipecten opercularis* in Europe

The queen scallop (*Aequipecten opercularis*) is distributed across European waters, with fisheries concentrated in the Irish Sea, Isle of Man, France, Scotland (including Shetland), Northern Ireland, and the Faroe Islands. These dredge fisheries are generally smaller in scale compared to king scallop fisheries and exhibit high spatial and temporal variability in recruitment, growth, and density.

Formal biological reference points for queen scallop stocks are largely absent across Europe, with the notable exception of the Isle of Man, which applies operational indicators. The Isle of Man uses LPUE thresholds and swept-area estimates to guide management (ICES 2024a). Given the distinct nature of fishing grounds and variability in stock dynamics, management increasingly occurs at the fine spatial scale of individual grounds rather than relying on broad-scale assessments. Elsewhere, including Scotland, Northern Ireland, and the wider Irish Sea, no formal reference points are in place, and management relies on effort controls and closures. In the Faroe Islands, no analytical stock assessment is available, but the fishery operates under a harvest control rule based on real-time catch rates. If catch rates fall below 1.5 tonnes gross per fishing hour, the vessel moves to another area, allowing depleted grounds to recover, typically over two years. This system functions as an implicit operational reference point.

Management of queen scallop fisheries in Europe is primarily effort-based and spatially adaptive. Licensing and seasonal closures are common, such as the Faroe Islands closure from April to August. Rotational area management is applied in some regions, and LPUE thresholds and swept-area estimates are used in the Isle of Man. Real-time catch-based triggers in the Faroe Islands help prevent local depletion, and there is increasing emphasis on fine-scale management to address spatial heterogeneity in stock dynamics.

4.7 *Chlamys islandica* in Europe

The Icelandic scallop (*Chlamys islandica*) occurs in cold-water habitats across the North Atlantic, supporting small-scale fisheries in Iceland and Norway. These fisheries are relatively data-limited compared to other scallop species, and current management approaches reflect the challenges of sparse time series, uncertain spatial stock structure, and limited life-history information.

In Iceland, the scallop fishery is assessed by the Marine and Freshwater Research Institute using a length-based fishing pressure proxy calculated as natural mortality divided by mean shell length. This proxy serves as a reference point for evaluating exploitation relative to biological limits. The approach is suited to data-limited contexts where age-based models are impractical. Annual assessments incorporate dredge survey data and length-frequency distributions to estimate stock status and guide management advice (Marine and Freshwater Research Institute 2025).

In Norway, reference point development is strongly influenced by the rapid collapse of the offshore *C. islandica* fishery (Strand & Vølstad 1997, Duncan et al. 2016, ICES 2017). After extensive beds were discovered in the 1970s, landings surged to more than 44 000 t by 1987 as large ocean-going vessels towing multiple dredges operated with minimal regulation. Intensive exploitation rapidly drove stocks to severe depletion, prompting the closure of major grounds beginning with Jan Mayen in 1987 and followed by Bear Island and Moffen (Spitsbergen) in 1989. Surveys during and after these closures showed only partial recovery at a few Svalbard beds: although density and recruitment increased, catch rates remained five to seven times lower than at the start of the fishery, reflecting persistent depletion linked to slow growth and episodic recruitment. This history informs the cautious reopening of a trial fishery in the Svalbard region, restricted to a single vessel and employing new suction-based harvesting gear intended to reduce seabed disturbance relative to conventional dredging (ICES 2024a). Provisional reference points derived from an age-based shortcut Management Strategy Evaluation method ($F_{MSY} = 0.25$; precautionary fishing mortality proxy $F_{pgy} = 0.19$) provide interim guidance for sustainable exploitation under substantial uncertainty. However, the advice notes significant limitations, including the very recent nature of the trial fishery, insufficient time series for robust assessment, spatial stock structure not accounted for in the evaluation, and limited knowledge of life-history parameters. The combination of past depletion and current uncertainty highlights the need for conservative harvest controls, spatially explicit management, and robust monitoring to avoid repeating earlier collapses.

Both Iceland and Norway employ precautionary, adaptive management approaches suited to data-limited fisheries. In Iceland, annual assessments using length-based indicators guide advice to maintain exploitation below the fishing pressure proxy threshold. In Norway, the trial fishery is regulated under precautionary F_{MSY} and F_{pgy} values, with an emphasis on monitoring and improving knowledge of stock structure and life history. Together, these strategies reflect the data-limited nature of the fisheries, prioritising conservative harvest levels and ongoing research to refine reference points for *C. islandica*.

5 KEY DESIGN CONSIDERATIONS FOR SCALLOP REFERENCE POINTS

International experience suggests that for sustainable scallop fisheries, reference points should be grounded in a sound understanding of scallop biology/ecology and the nature of the fishery, including spatial dynamics and the influence of environmental variability. While knowledge gaps are inevitable, to be effective, reference points must be developed based on the best available data and aligned with management objectives. They must also be applied at appropriate spatial scales. The overarching goal is to maintain spawning densities and protect habitats critical to recruitment, survival and growth. Key design considerations for scallop reference points are outlined below.

5.1 Spatial dynamics and scale

Scallop populations and fisheries are strongly structured in space. Populations vary in density, growth, mortality, recruitment, and habitat suitability, while fisheries concentrate effort on high-density beds to maximise catch rates. This heterogeneity underpins the need for reference points that reflect local ecological conditions.

Choosing the right spatial scale is critical. Reference points set too broadly risk obscuring local dynamics, while overly fine scales may be limited by data availability or management feasibility. Ideally, reference points should align with biologically meaningful units, such as substocks or regional populations, while also reflecting the resolution of survey data and fishery operations. Applying reference points at subregional levels (e.g., specific beds or zones) enables more responsive management, supports spatially explicit harvest control rules, and improves detection of localised depletion or recovery.

5.2 Biological and ecological considerations

The biological and ecological characteristics of scallops provide the foundation for setting meaningful reference points. Scallops are relatively short-lived, fast-growing bivalves with highly variable recruitment, and their population dynamics are strongly influenced by density-dependent processes. Successful fertilisation requires sufficient adult densities, meaning that critical thresholds exist below which reproductive output may collapse due to Allee effects (Levitan & Sewell 1998). Unfortunately, these dense aggregations are often the primary targets for scallop fishers seeking high catch rates. Modelling studies indicate that even moderate exploitation can significantly reduce larval output in sedentary invertebrates (Claereboudt 1999). A practical strategy to prevent recruitment overfishing is to leave some high-density adult scallop beds undisturbed within each management area. Hart et al. (2020) provided strong evidence that scallop fishery closures can induce increased recruitment in down-current areas.

Recruitment variability is further shaped by larval dispersal and settlement success, which depend on local hydrodynamics and habitat quality. Scallop beds function as semi-discrete populations, connected through larval transport but vulnerable to local depletion. Habitat features such as sediment type, filamentous algae, and benthic community structure play a central role in spat settlement, survival and growth, while predation and competition from other benthic species add additional ecological pressures.

These biological realities highlight the importance of recognising minimum viable densities, accounting for metapopulation connectivity, and safeguarding essential habitats. They provide the ecological context within which analytical approaches and management targets must be developed, ensuring that reference points are grounded in the species' life history and ecological dependencies.

5.3 Dynamic productivity

Scallop productivity is shaped by both environmental variability (i.e., changes in the supporting environment and associated species, e.g., resulting from oceanographic forcing and land-based sedimentation) and the effects of fishing (e.g., incidental mortality and reduced growth from discards and unobserved dredge contact, and degradation of benthic habitats essential for scallop survival and recruitment). Climate patterns such as the El Niño–Southern Oscillation (ENSO) may influence scallop abundance and recruitment. Tuck (2011) suggested a potential link between ENSO phases and scallop dynamics in northeastern New Zealand, based on analyses presented to the Shellfish Working Group (though not documented in the final report), and further investigation is needed to assess whether environmental indicators could be integrated into scallop stock assessments to provide predictive capacity and support adaptive decision-making.

International and domestic discussions have highlighted the challenges of managing scallop fisheries under changing productivity regimes (DFO 2013, Williams 2021a, b, 2022). The environment is inherently variable across both space and time, but beyond short-term natural variability, there is growing interest in whether long-term environmental changes may be contributing to declining scallop productivity. For example, in the Marlborough Sounds, productivity has declined in Pelorus Sound relative to Queen Charlotte Sound, which might be linked to changes in habitat suitability (Williams et al. 2024a). Distinguishing between fluctuations and persistent shifts is critical for understanding recruitment, growth, and recovery potential.

5.4 Limits, targets and indicators

To be sustainable, scallop fisheries require reference points that maintain spawning densities and protect habitat. These should include:

- **Biomass limits**: Soft and hard limits based on effective spawning biomass (i.e., the biomass that matters for reproduction), recognising that historical B_0 may be inappropriate for scallops where habitat has been lost. Per-bed density can provide a more meaningful index, as it reflects the biomass of scallops at ecologically relevant densities within high-density beds.
- **Harvest targets**: Conservative exploitation rates, particularly in open fishery areas with large scallops. Dredging may need to avoid habitats where juveniles are abundant due to its higher ecological impact, while lower exploitation rates overall are needed to ensure sustainability.
- **Indicators**: To track effective spawning stock size (adult biomass at higher densities), fishing mortality (catch/biomass) and habitat suitability (area of suitable benthic habitat) regional indicators are needed. These measures provide the basis for assessing status against reference points.

To be effective, reference points need to be embedded within a spatial management system that combines open and closed areas, ideally supported by maps of scallop distribution and habitat. Such systems help maintain high catch rates while minimising impacts on benthic ecosystems. To protect vulnerable habitats used by scallops and associated species such as dog cockles, horse mussels, sponges, and tubeworms, the management system should control overall harvest, including recreational take, and regulate fishing methods.

Parsons et al. (2024), in a Sustainable Seas National Science Challenge study, reviewed indicators for scallops to support ecosystem-based fisheries management in Tīkapa Moana / Hauraki Gulf, reinforcing the importance of integrating habitat suitability alongside biomass and fishing mortality measures.

To assess the condition and availability of suitable benthic environments, habitat reference points are needed in addition to stock-based measures. To be effective, scallop fishery management has to integrate habitat conservation with biomass preservation, embedding habitat considerations as a core element of the management framework.

Fenton et al. (2025), in their comparison of MSC-certified and uncertified scallop fisheries, highlighted the multiple benefits of mainstreaming habitat management within an ecosystem-based approach. Although their analysis did not explicitly address reference points, it emphasised the critical role of habitat in sustaining stock dynamics and ecosystem resilience, both of which are essential for long-term fisheries sustainability. Excluding scallop fishing from certain areas can maintain high broodstock densities, reduce gear impacts that lower fecundity and protect habitats vital for spat settlement and nursery functions.

A practical example of integrated habitat-focused management is the Isle of Man's Long-Term Management Plan for the king scallop fishery (Department of Environment Food and Agriculture

2022). Regular seabed assessments inform spatial management decisions, including area closures and gear restrictions, helping to safeguard sensitive benthic habitats and maintain ecological integrity.

5.5 Analytical approaches

Reference points can be developed using two main analytical approaches: modelling, which simulates biological processes; and empirical methods, which use observed data. Both have strengths and weaknesses and can be used independently or in combination to support evidence-based decisions.

YPR modelling approaches have been used in New Zealand, however, these depend on comprehensive data inputs and rely heavily on assumptions about biological and fishery processes, some of which are uncertain or poorly supported. Given the limited data for many New Zealand scallop populations, concerns remain about the reliability of these assumptions and the accuracy of model estimates.

An alternative is to build on the empirical method developed for scallops in the Marlborough Sounds, which relies on real-world observations and avoids heavy dependence on theoretical assumptions. This empirical approach is especially useful when modelling is constrained by data limitations or when model uncertainty is too high. For example, proxies for fishing mortality (F) and biomass at MSY (B_{MSY}) can be estimated from local time series of effective SSB and catch, using scallop spatial density thresholds informed by field data.

As Cadrin (2024) noted, modelling can be adapted to sedentary shellfish fisheries if spatial patterns in fishing and productivity are well represented in the available data. For New Zealand scallops, empirical approaches are currently more appropriate, with modelling becoming feasible only once sufficient data are available to reliably capture spatial patterns in fishing activity and scallop productivity.

6 DISCUSSION

This review synthesises key insights into the development and application of reference points in scallop fisheries. Within New Zealand, we evaluated previously applied reference points, identifying their strengths, limitations, and implementation gaps. Internationally, we examined a range of modelling and empirical approaches, highlighting their applicability across diverse management settings. From this review, the critical design considerations for effective reference points were identified.

In New Zealand, yield-per-recruit (YPR) modelling has been used to estimate target fishing mortality rates for the Northland, Coromandel and Marlborough Sounds scallop fisheries. While modelling provides a useful framework, its application is constrained by the complexity of scallop population and fishery dynamics, which are often oversimplified in theoretical models. Recognising these limitations, assessments in the Marlborough Sounds shifted to an empirical approach, producing substock-wide reference points for harvest rate (U) targets and absolute biomass (B) soft and hard limits. However, biologically meaningful limit reference points have yet to be formally established.

Scallop fisheries in Australia, Europe and North America included in this review represent diverse species, stock sizes, and management approaches, yet they share common challenges: sustainability concerns, pronounced spatio-temporal variability, and data limitations. Some fisheries have well-established reference points, while others are still developing them. Most rely on MSY frameworks, using SSB limits and F targets. These fisheries are typically monitored by conducting regular, often annual, fishery-independent surveys and through fine-scale fishery data collection, which provide the basis for stock assessments and management decisions.

Alongside reference points, complementary strategies play a critical role. A defining feature of productive overseas scallop fisheries is the use of adaptive spatial management systems, which allow areas to be opened or closed based on current information on scallop distribution, abundance and size structure. These systems help protect juvenile scallops, maintain adequate spawning biomass, and enhance ecological resilience and fishery performance.

This work also builds on previous reviews, including the 2016 international panel assessment of New Zealand's scallop stock assessment data and methods (Smith et al. 2016) as well as broader evaluations by ICES, Cadrin, and Daleo. Key points from these reviews emphasised the need for robust empirical data, spatially explicit management approaches, and improved integration of ecological considerations into reference point design.

Overall, New Zealand's approaches are broadly consistent with international practice. However, significant refinement is possible, particularly to address the inappropriate use of absolute biomass in harvest rate calculations. Developing spatially explicit reference points and incorporating changing productivity and habitat considerations into the management framework would provide further improvements. These refinements would help ensure that New Zealand's scallop fisheries are managed in line with best practice and remain resilient under dynamic ecological conditions.

7 REVIEW RECOMMENDATIONS

The following review recommendations outline a suggested pathway for developing improved reference points for New Zealand scallops. They progress logically from ecological foundations through to monitoring and management, so that each step builds on the last. Collectively, they address key questions identified during the review: where management should occur, how effective spawning stock biomass (SSB) should be measured, how limits and targets should be set, how to adapt to change, how to monitor, and how to integrate these elements into effective management plans.

7.1 Define appropriate spatial scales

To be effective, scallop assessment and management have to occur at spatial scales that appropriately reflect population connectivity and local ecological dynamics. Reference points have to capture these processes rather than broad stock-wide averages. Management units need to balance biological relevance with practicality: small enough to encompass ecological linkages, yet large enough to be feasible to implement.

7.2 Establish critical density thresholds

Critical density thresholds are needed both for defining exploitable biomass for viable fishing as well as effective SSB for scallop reproduction. Ideally, fishing thresholds could be based on scallop density data from historically fished areas, while effective SSB thresholds should reflect observations from healthy scallop beds supporting successful reproduction. Because survey methods vary in resolution (e.g., dredge tows versus dive transects), methodological variation differences would have to be taken into account when estimating density. Applying these thresholds to survey data would enable biomass re-estimation and the development of time series of exploitable biomass and effective SSB.

7.3 Develop empirically derived reference points

Given the limited data available for modelling approaches, precautionary management of New Zealand scallop fisheries requires the development of empirically derived, spatially explicit (sub-stock level) reference points reflecting present-day conditions, including:

- Effective SSB hard and soft limits to maintain minimum spawning biomass.
- Harvest rate (U) targets tailored to fishing method and stock status.

Limit reference points remain consistent across gear types because they represent the minimum effective spawning stock biomass that must be maintained regardless of how scallops are harvested. Target reference points, however, differ: dredging requires lower harvest rate targets due to its greater habitat disturbance and incidental effects on scallops, while diving has minimal effects and can support higher harvest rates. Different harvest rate targets are also needed depending on stock status. Healthy stocks can sustain higher yields, whereas recovering stocks require more conservative harvest targets to promote rebuilding. For depleted stocks, target reference points are academic until recovery begins.

Selecting an appropriate reference period is critical because perceived stock status can vary depending on the productivity regime used to define reference points (Hebert et al. 2025). Reference points may need to account for persistent, system-level changes in productivity, but they should not be revised so often that management end up responding to short-term environmental variability. Evidence of long-term change, such as sustained shifts in population trends or contraction of the area occupied by scallops, should be assessed carefully, and any revisions made cautiously.

Changes to limit reference points, which serve as biologically meaningful safeguards against stock depletion and collapse, should occur only when there is strong confidence that the existing values are no longer appropriate. In most cases, these limits should continue to be informed by the full historical dataset. Target reference points, which guide harvest control and help maintain healthy stocks, can be updated more readily when productivity regimes undergo a lasting transition rather than a temporary fluctuation.

In data-limited situations, the threshold for altering any reference point should be even higher to avoid reacting to short-term noise or making poorly supported adjustments. Regular review remains important, but updates should occur only when new information clearly indicates a sustained change in the system.

7.4 Maintain ongoing monitoring

Natural variability in scallop populations will always be present, so to track variability, assess performance against reference points, and support adaptive management (e.g., by adjusting catch levels in line with biomass) ongoing monitoring is required. Experience in overseas scallop fisheries has found that regular surveys are a core component of effective management.

Key indicators for monitoring could include:

- Effective SSB (e.g., the biomass of sexually mature scallops $\geq$ 70 mm shell length at viable densities to ensure successful spawning and fertilisation) (see Williams & Babcock 2005).
- Harvest rate (U, calculated as the ratio of catch to biomass), indicating fishing pressure.
- Habitat suitability metrics (such as area of suitable benthic habitat), contextualising stock distribution and productivity potential.

7.5 Develop integrated management plans

Integrated management plans are needed to bring these elements together into coherent, operational strategies. A central component of such plans is the establishment of reference points, supported by clear objectives that balance sustainability (maintaining minimum effective SSB and protecting habitats) with utilisation (enabling scallop harvesting with habitat-sensitive methods in defined areas at constrained levels to prevent local overfishing and habitat degradation).

Initial progress toward integrated management planning has already occurred in the South Island's SCA 7 fishery, through development of the Marlborough Sounds Southern Scallop Strategy (Southern Scallop Working Group & Fisheries New Zealand 2020) and its associated implementation plan (see https://www.mpi.govt.nz/consultations/draft-marlborough-sounds-scallop-strategy).

Progress in the North Island's SCA CS and SCA 1 fisheries is also advancing through Revitalising the Gulf (New Zealand Government 2021), the government's strategy for delivering a healthier Hauraki Gulf. The strategy seeks two overarching outcomes — effective kaitiakitanga and guardianship in the Gulf, and healthy functioning ecosystems — and identifies fisheries management as one of its eight core elements. Work under this element has included establishing the Hauraki Gulf Fisheries Plan Advisory Group (HGFPAG) and the development of the Hauraki Gulf Fisheries Plan (Fisheries New Zealand 2023). The plan contains two scallop-specific Management Actions: 1.1.2, to develop and implement a plan for managing the scallop fishery in the Hauraki Gulf; and 1.1.3, to identify funding opportunities and support research into alternative methods for scallop harvesting. These matters have since been explored in greater depth through iwi and multisector discussions at HGFPAG scallop workshops held in December 2024, February 2025 and November 2025.

Marine protection is another core element of the Hauraki Gulf Fisheries Plan (Fisheries New Zealand 2023) and is particularly relevant to scallop fisheries management because closed areas can protect high-density scallop broodstock beds from fishing. To ensure spatial relevance, reference points should apply to the surveyed portions of fished areas, while closed areas may contribute to effective SSB limits depending on connectivity and recruitment dynamics. New marine protection areas (MPAs) established in the Hauraki Gulf in October 2025 (DOC 2025) may offer additional potential protection for scallop beds, although initial indications suggest generally low abundance in these areas (J. Williams, pers. obs.). Earth Sciences New Zealand (formerly NIWA) is working with DOC to develop a scallop monitoring programme for these MPAs. Baseline data on scallops and habitats were collected during joint ESNZ–DOC fieldwork in June and November 2025 using dive and camera transect surveys across key sites in some of the MPAs (Williams in prep).

8 POTENTIAL RESEARCH

To make progress on the recommendations suggested above, short-term research priorities could include using the best available existing knowledge to:

- **Refine spatial scales**. Apply insights from population connectivity studies (Silva 2015, Silva & Gardner 2015, 2016, Silva et al. 2019) and current modelling (e.g., led by University of Auckland; A. Jeffs, pers. comm.) to validate appropriate assessment and management units.
- **Validate density thresholds**. Identify and examine data to determine critical density thresholds required for effective SSB.
- **Derive empirical effective SSB limits**. Reanalyse survey data (Williams et al. 2024a, Williams et al. 2024b, Williams et al. 2025) using thresholds to generate time series of effective SSB for setting limits and recruited biomass for setting targets.
- **Improve harvest rate targets**. Combine fishery data and biomass data to calculate harvest rates for representative periods, addressing the challenge of coarse spatial resolution.
- **Test productivity regimes**. Assess evidence for shifts in productivity; if stable, use reference periods; if shifting, adapt reference points to current conditions.
- **Advance monitoring design.** Develop a feasible monitoring plan that will reliably track indicators of stock status relative to reference points.

To further strengthen the scientific basis for scallop reference points by addressing key knowledge gaps, long-term research priorities should focus on targeted research that:

- Investigates stock connectivity and its implications for management units
- Determines threshold densities required for effective reproduction
- Assesses how environmental variability influences scallop dynamics.

9 FULFILMENT OF BROADER OUTCOMES

The Government recognises that its procurement activities offer a unique opportunity to achieve broader cultural, economic, environmental, and social outcomes for New Zealand. All Government agencies are expected to leverage their procurements to achieve these broader outcomes. In the present study, Earth Sciences New Zealand was committed to using this scallop research project to address the following broader outcomes:

- Taking care of the environment. This research has emphasised the importance of habitat considerations in the development of reference points for scallops, reinforcing the importance of ecosystem-based approaches to fisheries management.
- Building capacity and capability, and increasing diversity and inclusion, in the research sector. The project team included both early/mid–career and senior scientists, with notable female leadership of the initial literature review work and the implementation of the reference points online questionnaire.
- International collaboration. We actively engaged with global experts through participation in the ICES Scallop Assessment Working Group (WGScallop) and the International Pectinid Workshop (IPW), fostering knowledge exchange and strengthening New Zealand's research capability.
- Commitment to becoming Zero Waste. The project adopted a predominantly paper-free approach, reflecting dedication to sustainable research practices.

10 ACKNOWLEDGEMENTS

This work was completed under Objectives 1–2 of Fisheries New Zealand project SCA2022-01. We thank Marine Pomarède and Ian Tuck (Fisheries New Zealand Science Team) for project coordination and their review of this document. We gratefully acknowledge the members of the ICES Scallop Assessment Working Group (WGScallop) and participants of the 2024 International Pectinid Workshop (IPW) for their valuable insights and contributions, and extend our sincere thanks to the following international scallop researchers who contributed to our online questionnaire and/or reviewed an earlier draft and provided feedback and further information that helped to improve this review: Lynda Blackadder (Marine Directorate, Scotland, UK), Connor Buckley (New England Fishery Management Council, USA), Luis Cruz (Faroe Marine Research Institute, Faroe Islands), Adam Delargy (University of Massachusetts Dartmouth, USA), Helen Dobby (Marine Directorate, Scotland, UK), Ellen Grefsrud (IMR, Norway), Leander Harlow (UHI Shetland, Scotland, UK), Dvora Hart (NOAA, USA), Natalie Hold (Bangor University, Wales, UK), Jacob Kasper (MFRI, Iceland), David Keith (Fisheries and Oceans Canada, Canada), Mario Lasta (INIDEP, Argentina), Luz Pérez-Parallé (University of Santiago de Compostela, Spain), Oliver Tully (Marine Institute, Ireland), and Fabian Zimmermann (IMR, Norway). Appreciation is extended to Fisheries New Zealand's Shellfish Fisheries Assessment Working Group for their peer-review of the methods and results. Special thanks to Jeremy McKenzie and Richard O'Driscoll for reviewing earlier draft versions of this report.

11 REFERENCES

Australian Fisheries Management Authority (2015). Harvest strategy for the Bass Strait Central Zone Scallop Fishery. Australian Government. June 2015.

https://www.afma.gov.au/sites/default/files/2023-02/Bass%20Strait%20Central%20Zone%20Scallop%20Fishery%20Harvest%20Strategy.pdf. 8 p.

Australian Fisheries Management Authority (2025a). Bass Strait Central Zone Scallop Fishery Management Arrangements Booklet. Australian Government. https://www.afma.gov.au/commercial-fishers/management-arrangements/management-booklets#referenced-section-1. 42 p.

Australian Fisheries Management Authority (2025b). Bass Strait Central Zone Scallop Fishery. Website. https://www.afma.gov.au/fisheries/bass-strait-central-zone-scallop-fishery

Beverton, R.J.H.; Holt, S.J. (1957). On the dynamics of exploited fish populations. *U.K. Ministry of Agriculture and Fisheries, Fisheries Investigations (Series 2) 19*: 1–533.

Blake, S.; Bromhead, D.; Clayton, C.; Cao, A. (2025). Bass Strait Central Zone Scallop Fishery. *In*: I Butler, H.P., RS Cottrell, D Bromhead, D Galeano, T Timmiss, J Woodhams and R Curtotti (ed.). *Fishery status reports 2025, Australian Bureau of Agricultural and Resource Economics and Sciences, Canberra, DOI: https://doi.org/10.25814/ewe9-4p7. CC BY 4.0.*, pp.

Bloor, I.S.M. (2021). Evidence base to accompany the Isle of Man King Scallop Long Term Fisheries Management Plan Consultation. Bangor University Sustainable Fisheries and Aquaculture Group, Fisheries Report. 9 p.

Bloor, I.S.M.; Coleman, M.T.; Jenkins, S.R. (2024). Isle of Man King Scallop 2024 Stock Survey Report. Fisheries Report, Bangor University Sustainable Fisheries and Aquaculture Group. 54 p.

Bloor, I.S.M.; Duncan, P.F.; Dignan, S.P.; Emmerson, J.; Beard, D.; Gell, F.R.; McHarg, K.; Kaiser, M.J. (2021). Boom not bust: Cooperative management as a mechanism for improving the commercial efficiency and environmental outcomes of regional scallop fisheries. *Marine Policy 132*: 104649.

Brand, A.R. (2016). Scallop Ecology: Distributions and Behaviour. *In*: Shumway, S.E.; Parsons, G.J. (eds.) *Scallops: Biology, Ecology, Aquaculture and Fisheries*, pp. 469–533. *Developments in Aquaculture and Fisheries Science 40*. Elsevier, Amsterdam, Netherlands.

Breen, P.A. (1995). Report on MLS implications for Challenger scallops. MAF Fisheries Marine Research Report Wellington, N.Z. 9 p.

Breen, P.A.; Kendrick, T.H. (1999). Survey of scallops and oysters in Golden Bay, Tasman Bay, and Marlborough Sounds in June 1999. NIWA Client Report WLG99/30. 37 p.

Bull, M.; Drummond, K. (1994). Report on Tasman Bay and Golden Bay scallop mortality trials. MAF Central Fisheries Region Internal Report No. 24. MAF, Nelson, N.Z. 17 p.

Caddy, J.F. (1989). Marine Invertebrate Fisheries: Their Assessment and Management. Wiley, New York. 768 p.

Cadrin, S.X. (2024). Management reference points for sedentary shellfish fisheries. *Journal of Shellfish Research 43*: 145–155.

Cappell, R.; Huntington, T.; Nimmo, F.; MacNab, S. (2018). UK scallop fishery: current trends future management options and recommendations. . Report produced by Poseidon Aquatic Resource Management Ltd. p.

Caputi, N.; Chandrapavan, A.; Kangas, M.; de Lestang, S.; Hart, A.; Johnston, D.; Penn, J. (2021). Stock-recruitment-environment relationships of invertebrate resources in Western Australia and their link to pro-active management harvest strategies. *Marine Policy 133*: 104728.

Chandrapavan, A.; Jesson-Kerr, M. (2023). Ballot's Saucer Scallop (2023). Status of Australian Fish Stocks Report. Department of Primary Industries and Regional Development, Western Australia & Department of Agriculture and Fisheries, Queensland. 8 p. (https://fish.gov.au/Archived-Reports/2023/Ballot's%20Saucer%20Scallop%20%282023%29.pdf).

Claereboudt, M.R. (1999). Fertilization success in spatially distributed populations of free-spawners: a simulation model. *Ecological Modelling 121*: 221–233.

Coughlan, E. (2023). An assessment of sea scallop (*Placopecten magellanicus*) on St. Pierre Bank in 2019. 30 p.

Cranfield, H.J.; Michael, K.P.; Doonan, I.J. (1997). Biomass of scallops and oysters in Golden Bay, Tasman Bay and the Marlborough Sounds, 1997. NIWA Client Report WLG1997/27. 22 p.

Cryer, M. (1994). Estimating CAY for northern commercial scallop fisheries: a technique based on estimates of biomass and catch from the Whitianga bed. *New Zealand Fisheries Assessment Research Document 94/18*. 21 p.

Cryer, M.; Davies, N.M.; Morrison, M. (2004). Collateral damage in scallop fisheries: translating "statistics" into management advice. Presentation to the Shellfish Fishery Assessment Working Group, March 2004. (Unpublished presentation held by Fisheries New Zealand, Wellington, N.Z.) 18 p.

Cryer, M.; Morrison, M. (1997). Yield per recruit in northern commercial scallop fisheries: inferences from an individual-based population model and experimental estimates of incidental impacts on growth and survival. Final Research Report for Ministry of Fisheries Project AKSC03. 32 p.

Cryer, M.; Parkinson, D.M. (2006). Biomass surveys and stock assessments for the Coromandel and Northland scallop fisheries, 2005. *New Zealand Fisheries Assessment Report 2006/34*. 53 p.

Daleo, P. (2024). Review of biological reference points (BRPs) and harvest control rules (HCRs) used by MSC-certified scallop fisheries as well as for other (mostly) sedentary benthic species. Instituto de Investigaciones Marinas y Costeras. https://www.iimyc.gob.ar/iimyc/wp-content/uploads/2024/08/Informe_32.pdf. 9 p.

Department of Environment Food and Agriculture (2022). A Long-Term Management Plan for the Isle of Man King Scallop Fishery. Report produced by the Isle of Man Government, Bangor University, and the Isle of Man Scallop Management Board. 78 p.

Department of Environment Food and Agriculture (2023). Fisheries management plan for king scallops in English and Welsh waters. https://www.gov.uk/government/publications/king-scallop-fisheries-management-plan-fmp/fisheries-management-plan-for-king-scallops-in-english-and-welsh-waters

Department of Environment Food and Agriculture (2024). Manx King Scallop Fishery – 2024/25 Guidance Document. Isle of Man Government report. 6 p.

Department of Environment Food and Agriculture (2025). Manx King Scallop Fishery – 2024/25 Summary Report. Isle of Man Government report. 12 p.

Department of Fisheries (2020). Saucer Scallop Resource of the Abrolhos Islands Harvest Strategy: 2020 - 2025: Version 1.1. Government of Western Australia Department of Fisheries, Perth. Article. https://library.dpird.wa.gov.au/fr_fmp/291. 31 p.

DFO (2013). Proceedings of the National Workshop for Technical Expertise in Stock Assessment (TESA): Maximum Sustainable Yield (MSY) Reference Points and the Precautionary Approach when Productivity Varies; December 13-15, 2011. . DFO Canadian Science Advisory Secretariat Proceedings Series 2012/055. 58 p.

DFO (2023). Scallop stocks assessment in Quebec coastal waters in 2022. DFO Canadian Science Advisory Secretariat Report 2023/034. 22 p.

DFO (2024a). Southern Gulf of St. Lawrence, NAFO Division 4T, sea scallop (*Placopecten magellanicus*) stock assessment to 2023. DFO Canadian Science Advisory Secretariat Report 2024/037. 9 p.

DFO (2024b). Stock status update of Browns Bank North scallops (*Placopecten magellanicus*) for the 2024 fishing season. DFO Canadian Science Advisory Secretariat Report 2024/022. 9 p.

DFO (2024c). Stock status update of Georges Bank ‘a’ scallops (*Placopecten magellanicus*) for the 2024 fishing season. DFO Canadian Science Advisory Secretariat Report 9 p.

Dobby, H.; Miethe, T.; Barreto, E.; Cole, H. (2025). Scottish Scallop Stocks: Results of 2023 Stock Assessments. *Scottish Marine and Freshwater Science Vol 16 No 3*: 190 p.

DOC (2025). Hauraki Gulf/Tīkapa Moana marine protected areas. https://www.doc.govt.nz/parks-and-recreation/places-to-go/auckland/hauraki-gulf-marine-park/hauraki-gulf-marine-protected-areas/

Drummond, K. (1994). Estimates of abundance and yield for the Southern Scallop Fishery in the 1994 season. MAF Fisheries Central Region, Nelson, N.Z. 28 p.

Duncan, P.F.; Brand, A.R.; Strand, Ø.; Foucher, E. (2016). The European Scallop Fisheries for *Pecten maximus*, *Aequipecten opercularis*, *Chlamys islandica*, and *Mimachlamys varia*. *In*:

Shumway, S.E.; Parsons, G.J. (eds.) *Scallops: Biology, Ecology and Aquaculture*, pp. 781–858. Elsevier, Amsterdam, Holland.

Fenton, M.A.; Blackadder, L.; Stewart, B.D.; Donnan, D.; Hiddink, J.G.; Bell, M.C.; Kaiser, M.J. (2025). Mainstreaming habitat management objectives in an ecosystem-based approach to management of scallop fisheries. *Reviews in Fisheries Science & Aquaculture* 1–17.

Fisheries New Zealand (2023). Hauraki Gulf Fisheries Plan. August 2023. 24 p. (Available at: https://www.mpi.govt.nz/dmsdocument/58396/direct).

Fisheries New Zealand (2024). *Fisheries Assessment Plenary, November 2024: stock assessments and stock status*. Compiled by the Fisheries Science Team, Fisheries New Zealand, Wellington, New Zealand. 691 p.

Hale, R.; Lam-Gordillo, O.; Lohrer, D.; Williams, J.R.; Handley, S.; Olmedo-Rojas, P.; Middleton, I. (2024). Cumulative effects of stressors on scallops and scallop habitats in the Marlborough Sounds: With insights from sites in Northland, Hauraki Gulf, and eastern Coromandel Peninsula. *New Zealand Aquatic Environment and Biodiversity Report No. 337*. 109 p.

Harbicht, A.; Landry, L.; Niles, M. (2024). Southern Gulf of St. Lawrence scallop population model and limit reference point review. *DFO Canadian Science Advisory Secretariat Research Document 2024/035*: v + 96 p.

Hart, D.R. (2003). Yield- and biomass-per-recruit analysis for rotational fisheries, with an application to the Atlantic sea scallop (*Placopecten magellanicus*). *Fishery Bulletin 101*: 44–57.

Hart, D.R. (2013). Quantifying the tradeoff between precaution and yield in fishery reference points. *ICES Journal of Marine Science 70*: 591–603.

Hart, D.R.; Munroe, D.M.; Caracappa, J.C.; Haidvogel, D.; Shank, B.V.; Rudders, D.B.; Klinck, J.M.; Hofmann, E.E.; Powell, E.N. (2020). Spillover of sea scallops from rotational closures in the Mid-Atlantic Bight (United States). *ICES Journal of Marine Science 77*: 1992–2002.

Hebert, N.E.; Barrett, T.J.; Marentette, J.R.; Turcotte, F.; Hubley, B. (2025). Influence of time-varying productivity on fishery reference points and implications for conservation objectives and management advice. *Fisheries Research 291*: 107541.

Hubley, P.B.; Reeves, A.; Smith, S.J.; Nasmith, L. (2014). Georges Bank 'a' and Browns Bank 'North' Scallop (*Placopecten magellanicus*) Stock Assessment. *DFO Canadian Science Advisory Secretariat Research Document 2013/079*: vi + 58 p.

ICES (2017). Interim Report of the Scallop Assessment Working Group (WGScallop), 10–12 October 2017, Belfast, Northern Ireland, UK. ICES CM 2017/SSGEPD: 25. https://doi.org/10.17895/ices.pub.8462. 18 p.

ICES (2022a). Workshop on ICES reference points (WKREF1). ICES Scientific Reports. 4:2. 70 p. (http://doi.org/10.17895/ices.pub.9822).

ICES (2022b). Workshop on ICES reference points (WKREF2). ICES Scientific Reports. 4:68. 96 p. (http://doi.org/10.17895/ices.pub.20557008).

ICES (2024a). Scallop Assessment Working Group (WGScallop; outputs from 2024 meeting). ICES Scientific Reports. 6:104. https://doi.org/10.17895/ices.pub.28015394.v1 96 p.

ICES (2024b). Workshop on the calculation and evaluation of new reference points for category 1–2 stocks (WKNEWREF). ICES Scientific Reports. 6:100. 241 p. (https://doi.org/10.17895/ices.pub.27905664).

ICES (2026). Scallop Assessment Working Group (WGScallop; outputs from 2025 meeting). ICES Scientific Reports. 8:5. 113 p. (https://doi.org/10.17895/ices.pub.31149055).

Jonsen, I.D.; Glass, A.; Hubley, B.; Sameoto, J. (2009). Georges Bank 'a' Scallop (*Placopecten magellanicus*) Framework Assessment: Data Inputs and Population Models. *DFO Canadian Science Advisory Secretariat Research Document 2009/034*: iv + 76 p.

Kangas, M.; Chandrapavan, A.; Wilkin, S.; Caputi, N. (2022). Recovery trajectories and management responses for three scallop stocks over ten years following an extreme marine heatwave in Western Australia. *Frontiers in Climate 4*: 1043889.

Kangas, M.; Chandrapavan, A.; Wilkins, A.; Fisher, E.A.; Evans, S. (2021). Resource Assessment Report Abrolhos Islands and Mid-West Trawl Managed Fishery Resource. Department of Primary Industries and Regional Development, Perth. Report No. 20. https://library.dpird.wa.gov.au/fr_msc/3. 75 p.

Keith, D.M.; Keyser, F.; McDonald, R.; Pearo Drew, T.; Sameoto, J.A. (2025a). Stock Assessment Framework for Scallop Fishing Areas 25, 26, and 27B: Reference Points. DFO Canadian Science Advisory Secretariat Research Document 2025/083. v + 60 p. (https://waves-vagues.dfo-mpo.gc.ca/library-bibliotheque/4131198x.pdf).

Keith, D.M.; Keyser, F.; McDonald, R.; Pearo Drew, T.; Sameoto, J.A. (2025b). Stock Assessment Framework for Scallop Fishing Areas 25, 26, and 27B: Stock Assessment Models for SFAs 25A and 26A. DFO Canadian Science Advisory Secretariat Research Document 2025/066. v + 122 p. (https://waves-vagues.dfo-mpo.gc.ca/library-bibliotheque/41309108.pdf).

Knuckey, I.; Magnusson, A.; Koopman, M.; Carlin, L.; Dix, A.; Morison, J.; Sen, S. (2022). Informing the BSCZSF Harvest Strategy and TAC-setting with MEY calculations.

Koopman, M.; Knuckey, I. (2024). Bass Strait Central Zone Scallop Fishery – 2024 survey. 44 p.

Lawler, A.; Nawri, N. (2021). Assessment of king scallop stock status for selected waters around the English coast 2019/2020. *Cefas Project Report for Defra*

Lawler, A.; Nawri, N.; Harvey, J.; Clarke, D.; Vanstaen, K.; Benedet, R. (2022). Assessment of king scallop stock status for selected waters around the English coast 2020/2021.

Lawler, A.; Nawri, N.; Harvey, J.; Clarke, D.; Vanstaen, K.; Benedet, R. (2023a). Assessment of king scallop stock status for selected waters around the English coast 2021/2022. Centre for Environment, Fisheries and Aquaculture Science (CEFAS), UK. A Defra and Industry Funded Project. 78 p. (https://assets.publishing.service.gov.uk/media/642edd357de82b000c3137b2/SCE_assessment_report_2022_main_v2.pdf).

Lawler, A.; Nawri, N.; Harvey, J.; Clarke, D.; Vanstaen, K.; Benedet, R. (2023b). Assessment of king scallop stock status for selected waters around the English coast 2021/2022 – Annexe. Centre for Environment, Fisheries and Aquaculture Science (CEFAS), UK. A Defra and Industry Funded Project. 40 p. (https://assets.publishing.service.gov.uk/media/642edd64fbe620000f17de2d/SCE_assessment_report_2022_annexe_v2.pdf).

Levitan, D.R.; Sewell, M.A. (1998). Fertilization success in free-spawning marine invertebrates: review of the evidence and fisheries implications. *In*: Jamieson, G.S.; Campbell, A. (eds.) *Proceedings of the North Pacific Symposium on Invertebrate Stock Assessment and Management*, pp. 159–164. *Canadian Special Publication of Fisheries and Aquatic Sciences: 125*.

Marine and Freshwater Research Institute (2025). Iceland Scallop *Chlamys islandica*. Technical report: 6 June 2025. https://www.hafogvatn.is/static/extras/images/scallop_2025_techreport_en.html

McDonald, R.R.; Keith, D.M.; Sameoto, J.A.; Mills Flemming, J. (2023). Integrating habitat features into spatio-temporal biomass dynamics models for a better understanding of stock productivity: a case study of sea scallop in the Bay of Fundy. *ICES Journal of Marine Science 80*: 1710–1726.

Ministry of Fisheries (2008). Harvest Strategy Standard for New Zealand Fisheries. 25 p.

Ministry of Fisheries (2011). Operational guidelines for New Zealand's harvest strategy standard (Revision 1). Unpublished report held by Fisheries New Zealand, Wellington. 78 p.

New Zealand Government (2021). Revitalising the Gulf: Government action on the Sea Change Plan. 144 p. (https://www.mpi.govt.nz/fishing-aquaculture/sustainable-fisheries/strengthening-fisheries-management/revitalising-the-hauraki-gulf-government-action-on-the-sea-change-plan/).

Niles, M.; Barrell, J.; Sameoto, J.; Keith, D.; Sonier, R. (2021). Scallop Fishery Assessment of the Southern Gulf of St. Lawrence in 2018: Commercial Fishery and Survey Data. *DFO Canadian Science Advisory Secretariat Research Document* xii +178 p.

NIWA (2012). Information on drivers of shellfish production in Golden and Tasman Bays and knowledge gaps: A review to inform the development of a strategic research plan to rebuild shellfish fisheries in Golden and Tasman Bays. Working draft report prepared for iwi and stakeholders for the Rebuilding Shellfish Fisheries Workshop, 15th August, Nelson, N.Z. 53 p.

NOAA (2023). Atlantic Sea Scallop. Official website of the United States government. https://www.fisheries.noaa.gov/species/atlantic-sea-scallop

NOAA Fisheries (2025). Panel Summary Report of the Atlantic Sea Scallop Research Track Peer Review. Northeast Fisheries Science Center, Woods Hole, MA. Retrieved from https://www.fisheries.noaa.gov/s3/2025-05/Panel-Summary-Report-of-the-Atlantic-Sea-Scallop-Research-Track-Peer-Review-20250512_508.pdf. 37 p.

Northeast Fisheries Science Center (2018). 65th Northeast Regional Stock Assessment Workshop (65th SAW) Assessment Report. U.S. Department of Commerce, Northeast Fisheries Science Center Reference Document 18-11; available from: http://www.nefsc.noaa.gov/publications/. 659 p.

Northeast Fisheries Science Center (2020). Assessment update for Atlantic sea scallops for 2020. 6 p. (https://d23h0vhsm26o6d.cloudfront.net/1.b.i_-2020_scallop_unit_maindoc_rev.pdf).

Orensanz, J.M.; Jamieson, G.S. (1998). The assessment and management of spatially structured stocks: an overview of the North Pacific Symposium on Invertebrate Stock Assessment and Management. *In*: Jamieson, G.S.; Campbell, A. (eds.) *Proceedings of the North Pacific Symposium on Invertebrate Stock Assessment and Management*, pp. 441–459. *Canadian Special Publication of Fisheries and Aquatic Sciences: 125*.

Orensanz, J.M.; Parma, A.M.; Smith, S.J. (2016). Dynamics, Assessment and Management of Exploited Natural Populations. *In*: Shumway, S.E.; Parsons, G.J. (eds.) *Scallops: Biology, Ecology and Aquaculture*, pp. 611–695. Elsevier, Amsterdam, Holland.

Osborne, T.A. (1998). Biomass of scallops in Golden Bay, Tasman Bay and the Marlborough Sounds, 1998. Report 1001 by Osborne Research Company Ltd. (ORCO) for Challenger Scallop Enhancement Company Ltd. 32 p.

Parsons, D.; Middleton, I.; Karaka, D. (2024). Fisheries system indicators to support Ecosystem Based Fisheries Management in Tīkapa Moana, Te Moananui-ā-Toi. Report for Sustainable Seas National Science Challenge project EBFM in the Hauraki Gulf (Project code S4). 145 p.

Prager, M.H.; Porch, C.E.; Shertzer, K.W.; Caddy, J.F. (2003). Targets and limits for management of fisheries: A simple probability-based approach. *North American Journal of Fisheries Management 23*: 349–361.

Silva, C.N.S. (2015). Spatial and temporal genetic structure of the New Zealand scallop *Pecten novaezelandiae*: A multidisciplinary perspective. Unpublished PhD thesis. Victoria University of Wellington 158 p.

Silva, C.N.S.; Gardner, J.P.A. (2015). Emerging patterns of genetic variation in the New Zealand endemic scallop *Pecten novaezelandiae*. *Molecular Ecology 24*: 5379–5393.

Silva, C.N.S.; Gardner, J.P.A. (2016). Identifying environmental factors associated with the genetic structure of the New Zealand scallop: linking seascape genetics and ecophysiological tolerance. *ICES Journal of Marine Science: Journal du Conseil 73*: 1925–1934.

Silva, C.N.S.; Macdonald, H.S.; Hadfield, M.G.; Cryer, M.; Gardner, J.P.A. (2019). Ocean currents predict fine-scale genetic structure and source-sink dynamics in a marine invertebrate coastal fishery. *ICES Journal of Marine Science 76*: 1007–1018.

Smith, S.; Hart, D.; Haddon, M. (2016). Review of New Zealand's scallop fishery stock assessment data and methods. *New Zealand Fisheries Science Review 2016/1*. 25 p.

Smith, S.J.; Hubley, P.B. (2012). Reference points for scallop fisheries in the Maritimes Region. *Department of Fisheries and Oceans Canadian Science Advisory Secretariat Research Document 2012/018*: ii + 16 p. (Erratum: August 2012).

Smith, S.J.; Rago, P. (2004). Biological reference points for sea scallops (*Placopecten magellanicus*): the benefits and costs of being nearly sessile. *Canadian Journal of Fisheries and Aquatic Sciences 61*: 1338–1354.

Smith, S.J.; Sameoto, J.A.; Brown, C.J. (2017). Setting biological reference points for sea scallops (*Placopecten magellanicus*) allowing for the spatial distribution of productivity and fishing effort. *Canadian Journal of Fisheries and Aquatic Sciences 74*: 650–667.

Southern Scallop Working Group & Fisheries New Zealand. (2020). Southern Scallop Strategy: Marlborough Sounds. *https://www.fisheries.govt.nz/news-and-resources/consultations/draft-marlborough-sounds-scallop-strategy/?utm_source=notification-email*: 13 p.

Strand, Ø.; Parsons, J.G. (2006). Scallop fisheries and aquaculture in Scandinavia. *In*: Shumway, S.E.; Parsons, G.J. (eds.) *Scallops: Biology, Ecology and Aquaculture*, pp. 1067–1091. Elsevier, Amsterdam, Holland.

Strand, Ø.; Strohmeier, T.; Hjelset, A.M.; Grefsrud, E.S. (2016). Fangsteffektivitet i dykkebasert fiske etter stort kamskjell (*Pecten maximus*) i Sør-Trøndelag. In Norwegian. Fisken og havet 1/2016. Report from the institute of Marine Research, Bergen, Norway. 16 p.

Strand, Ø.; Vølstad, J.H. (1997). The molluscan fisheries and culture of Norway. *In*: MacKenzie Jr, C.L.; Burrell Jr, V.G.; Rosenfield, A.; Hobart, W.L. (eds.) *The History, Present Condition, and Future of the Molluscan fisheries of North America and Europe, Volume 3, Europe. 240 p.*, pp. 7–24. Department of Commerce, NOAA Technical Report NMFS 129.

Talman, S.G.; Norkko, A.; Thrush, S.F.; Hewitt, J.E. (2004). Habitat structure and the survival of juvenile scallops *Pecten novaezelandiae*: comparing predation in habitats with varying complexity. *Marine Ecology Progress Series 269*: 197–207.

Thrush, S.F.; Hewitt, J.E.; Cummings, V.J.; Dayton, P.K.; Cryer, M.; Turner, S.J.; Funnell, G.A.; Budd, R.G.; Milburn, C.J.; Wilkinson, M.R. (1998). Disturbance of the marine benthic habitat by commercial fishing - Impacts at the scale of the fishery. *Ecological Applications 8*: 866–879.

Truesdell, S.B.; Hart, D.R.; Chen, Y. (2016). Effects of spatial heterogeneity in growth and fishing effort on yield-per-recruit models: an application to the US Atlantic sea scallop fishery. *ICES Journal of Marine Science 73*: 1062–1073.

Tuck, I.D. (2011). Utility of scallop surveys in predicting future year's CAY. Final Research Report for Ministry of Fisheries Project SEA201011. 29 p.

Tuck, I.D.; Brown, S. (2008). Survey of scallops and oysters in Golden Bay, Tasman Bay, and the Marlborough Sounds, 2008. NIWA Client Report NEL2008-022. 37 p.

Tuck, I.D.; Williams, J.R.; Bian, R. (2018). SCA 7 dredge efficiency and fine scale catch modelling. Final Research Report Final Research Report for Ministry for Primary Industries Project SCA2017-02: Objectives 2 & 3. 19 p.

Western Australia. Dept. of Fisheries. (2015). Harvest strategy policy and operational guidelines for the aquatic resources of Western Australia. . *Western Australian Department of Fisheries, Perth. Report Fisheries Management Paper No. 271.* *https://library.dpird.wa.gov.au/fr_fmp/266*

Wiborg, K.F.; Bøhle, B. (1974). Occurrences of edible shellfish (bivalves) in Norwegian coastal waters (with a selection of marine gastropods). Fisheries and Marine Service Translation Series No. 2978. Department of the Environment, Canada. [Translated from Fiskets Gang 60(17): 307–313, 1974]. 34 p.

Williams, J.R. (2021a). Reference points for scallops in the Marlborough Sounds. Presentation to the MPI Statistical Assessment Methods Working Group. Online presentation via Teams, 1 April.

Williams, J.R. (2021b). Scallops. SAMWG meeting on dynamic reference points and representing fishing mortality. Presentation to the MPI Statistical Assessment Methods Working Group. Online presentation via Teams, 9 December.

Williams, J.R. (2022). Declining productivity: New Zealand scallop stocks. Presentation to the Joint US-NZ Meeting between University of Washington, NOAA fisheries, Fisheries New Zealand, NIWA and other fisheries researchers. Meeting topic: How climate change is impacting fisheries in the north-west US and New Zealand (and potentially elsewhere) and the utility of dynamic reference points. Online presentation via Teams, 17 May.

Williams, J.R. (in prep). Scallop monitoring programme for Tīkapa Moana / Hauraki Gulf marine protection areas. ESNZ Client Report Draft unpublished report for DOC held by ESNZ Auckland, New Zealand. xx p.

Williams, J.R.; Babcock, R.C. (2005). Assessment of size at maturity and gonad index methods for the scallop *Pecten novaezelandiae*. *New Zealand Journal of Marine and Freshwater Research 39*: 851–864.

Williams, J.R.; Bian, R. (2012). Survey of scallops and oysters in Golden Bay, Tasman Bay, and the Marlborough Sounds, 2012. NIWA Client Report AKL2012-032. 65 p.

Williams, J.R.; Bian, R. (2019). Revised estimates of biomass and exploitation, 1997-2018, Marlborough Sounds, SCA 7. Presentation to the MPI Shellfish Fisheries Assessment Working Group. MPI, Nelson, N.Z., 28 March.

Williams, J.R.; Bian, R.; Brown, S. (2009). Survey of scallops and oysters in Golden Bay, Tasman Bay, and the Marlborough Sounds, 2009. NIWA Client Report NEL2009-024. 37 p.

Williams, J.R.; Bian, R.; Carter, M.; Hughes, R.; Middleton, C.M.; Olsen, L.; Stead, J. (2024a). Dive and dredge surveys of scallops in SCA 7, 2021. *New Zealand Fisheries Assessment Report 2024/57*. 51 p.

Williams, J.R.; Bian, R.; Hartill, B. (2014a). Review of the difference between CAY estimates and actual catch for the Coromandel scallop (SCA CS) fishery. Final Research Report. 26 p.

Williams, J.R.; Bian, R.; Michael, K. (2010). Survey of scallops and oysters in Golden Bay, Tasman Bay, and the Marlborough Sounds, 2010. NIWA Client Report WLG2010-52. 54 p.

Williams, J.R.; Bian, R.; Middleton, C.M.; Hughes, R.; Evans, O.; Buckthought, D.; Parkinson, D.; Taylor, R. (2024b). Dive and dredge surveys of scallops in SCA 1 and SCA CS, 2021. *New Zealand Fisheries Assessment Report 2024/36*. 64 p.

Williams, J.R.; Bian, R.; Parkinson, D.M.; Roberts, C.L. (2015). Survey of scallops in Golden Bay, Tasman Bay, and Marlborough Sounds, 2015. NIWA Client Report AKL2015-019. 71 p.

Williams, J.R.; Bian, R.; Williams, C.L. (2013a). Survey of scallops in the Marlborough Sounds, 2013. NIWA Client Report AKL2013-015. 45 p.

Williams, J.R.; Bian, R.; Williams, C.L. (2014b). Survey of scallops in Golden Bay, Tasman Bay, and Marlborough Sounds, 2014. NIWA Client Report AKL2014-027. 63 p.

Williams, J.R.; Hartill, B.; Bian, R.; Williams, C.L. (2014c). Review of the Southern scallop fishery (SCA 7). *New Zealand Fisheries Assessment Report 2014/07*. 71 p.

Williams, J.R.; Hughes, R.; Jordan, L.; Middleton, C.J.; Middleton, I.; Underwood, M.J. (2024c). Camera survey of scallops in the SCA CS Te Hauturu-o-Toi/Little Barrier Island and Colville Channel areas, 2022. *New Zealand Fisheries Assessment Report 2024/66*. 39 p.

Williams, J.R.; Michael, K. (2011). Survey of scallops and oysters in Golden Bay, Tasman Bay, and the Marlborough Sounds, 2011. NIWA Client Report AKL2011-026. 64 p.

Williams, J.R.; Parkinson, D.M.; Bian, R. (2013b). Biomass survey and yield calculation for the Coromandel scallop fishery, 2012. *New Zealand Fisheries Assessment Report 2013/18*. 57 p.

Williams, J.R.; Tuck, I.D.; Hale, R.; Middleton, C.; Hughes, R.; Stead, J. (2024d). Habitat factors affecting scallop spat survival and growth in Golden Bay and Tasman Bay. *New Zealand Aquatic Environment and Biodiversity Report No. 342*. 67 p.

Williams, J.R.; Underwood, M.J.; Rensen, T.; Hughes, R.; Bian, R.; Middleton, C.; Evans, O.; Middleton, I. (2025). Camera, dive and dredge surveys of scallops in SCA 1 and SCA CS, 2024. *New Zealand Fisheries Assessment Report 2025/16*. 72 p.