

Best practices for managing, measuring and mitigating the benthic impacts of fishing

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Abstract

In a previous paper, [Review of habitat dependent impacts of mobile and static fishing gears that interact with the sea bed \(2014\)](#) we offered definitions for benthic habitat, fishing gear and fisheries management and a way of thinking about the challenge of understanding best practices for measuring, monitoring, managing and mitigating benthic impacts of fishing in the context of the MSC's certification requirements. These informed our review in the previous paper's classification of habitats and fishing gears and helped us highlight likely variations in benthic impact depending on habitat and gear used (Grieve, Brady & Polet, 2014). In this paper, we provide an overview of the systems used around the world to classify fisheries management systems. Best practices are related to the MSC Habitats performance indicators, as well as the themes for the original project: monitoring, measuring, managing and mitigating. We conclude the report with observations and recommendations that emerged from our review, with particular reference to defining habitat for MSC purposes and the information needs for certification bodies to make better assessments, e.g. understanding seabed characteristics, estimating fishing distribution, using local knowledge particularly when data are deficient, and the challenge of scaling up results of site-specific, intensive studies to the level of a fishery.

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Introduction: Classifying fisheries management systems

The MSC Fisheries Standard for Principle 3 – a fishery must meet all local, national and international laws and must have a management system in place to respond to changing circumstances and maintain sustainability (MSC 2014) make a useful distinction between two layers of fisheries management: (1) the overarching system, framework or regime that may inform the management of many fisheries, e.g. a national or international framework; and (2) the fishery-specific management system applied in an individual fishery, e.g. the specific rules and tools implemented to govern the extraction of species in a given area by an identifiable group of fishers. Therefore, in terms of understanding best practice for managing and mitigating the benthic impacts of fishing in relation to the MSC habitat component, classifications are presented at both the “systems” level and the “fishery-specific level”.

System level

At the overarching level (i.e. system, framework or regime), when thinking about the ecological dimension of ‘what’ is managed, fisheries management systems can be classified as:

- **Single species management** regimes where the primary focus of management attention is the target species. This system of management is unlikely to consider the broader impacts of fishing upon ecosystem components like habitats unless there is a direct correlation between the life history and therefore status of the target species and associated benthic habitat.
- **Multi-species management** regimes where the focus of management attention is on suites of species usually taken together or by the same fishing gear in the same geographical region. This is another species-led approach to fisheries management that may not consider the benthic habitat implications of fishing operations unless there is a correlation between the status of the species and the habitats in/on which fishing occurs. There may be considerable complexity introduced to the management process because of differing life histories, relationships and habitat associations.
- **Ecosystem-based fisheries management** regimes where the focus of fisheries management is on the broader components of ecosystems, including the sustainability of species taken (target and bycatch), as well as the impacts of fishing on other ecologically related species, endangered, threatened or protected species, habitats, and the productivity, diversity, structure and function of ecosystems. The impacts of fishing on all parts of exploited ecosystems are taken into consideration in management objectives and the management process. Increasingly, but not universally, concerns about the extent and effects (both indirect and direct) of fishing on habitats are being considered under such management regimes through international agreements, national laws and fishery management plans. Development of protective or restorative management strategies provide the means by which to mitigate degradation or loss of habitat structure as a fundamental component of ecologically sustainable fisheries (Turner *et al.* 1999).

- **Ecosystem-based management** regimes, sometimes referred to as '*integrated management*' or '*Marine Managed Areas*' (MMAs), of which commercial fishing is only one of multiple sectors managed along with other human activities in aquatic environments. Such sectors can include conservation, recreational angling and other recreational activity, non-renewable resource exploration and extraction, energy production, defence, shipping, tourism, marine archaeology and heritage, coastal zone development and terrestrial-based activities that impact upon aquatic ecosystems (e.g. water extraction, nuclear power generation, agricultural runoff, pollution, etc.). The aim of such regimes is, to the extent possible, strategically manage all human impacts on aquatic ecosystems, including habitats, and perhaps take in broader issues such as climate change. Sometimes this approach to management manifests as some form of national oceans policy or law, or a national or supranational marine spatial planning framework.

Governance in fisheries management systems may also be classified at the overarching level. This classification takes into account 'who' is involved in management and the roles governments, resource users and other stakeholders may play, or not, at the system level in fisheries policy and decision-making (Sen & Nielsen, 1996; Gutiérrez *et al.* 2011).

Such governance regimes can be classified along a spectrum (Sen & Nielsen, 1996) from centralised government through government-based co-management and stakeholder (including user)-based co-management to self-governing community-based management systems and traditional or customary marine tenure systems:



- **Centralised government** regimes involve command and control style management where there is no interaction between decision-makers and resource users or other stakeholders. Rules and regulations are defined, communicated and enforced.
- **Government-based management** regimes involve a minimal level of exchange of information telling users (*instructive* co-management regimes), or some consultation with users and/or other stakeholders (*consultative* co-management regimes), but ultimately all decisions are made by government.
- **Partnership-based management** regimes involve government and stakeholders, including resource users, as equal partners cooperating in all decision-making (*cooperative* co-management regimes).
- **Stakeholder-based management** regimes where stakeholders, including resource users, advise government of the decisions that are made and the government endorses and implements those decisions (*advisory* co-management regimes), or government has delegated decision-making authority to stakeholder groups who are required simply to inform government of their fisheries management decisions (*informative* co-management regimes).
- **Community-based fisheries management** regimes where there is no central government involvement in fisheries management. The responsibilities rest entirely with communities themselves, in this respect they might also be classified as *self-government* regimes.
- **Traditional or customary marine tenure** systems, like community-based or self-government fisheries management regimes, involve no government in fisheries management, but rather may involve kinship and lineage structures within communities, tenure may involve a spatial element where resources within an allocated area, as well as the area itself, belong to individuals, groups or communities.

As Sen & Nielsen (1996) and Gutiérrez *et al.* (2011) note, attempting to classify management regimes tends to oversimplify what are often complex and convoluted arrangements. The extent of involvement, its timing, task allocations, roles and responsibilities within collaborative or co-management regimes in complex socio-ecological contexts can vary immensely. In relation to MSC's treatment of habitats under its Certification Requirements and Guidance, however, such classifications may influence specific monitoring, measuring, managing or mitigating actions that might be implemented in a given fishery or fishery types. Best practice, as we have repeatedly noted, is contextual, but research has demonstrated that governance systems that combine both the 'what' and the 'who' appropriately lead to success (Gutiérrez *et al.* 2011). However, different combinations of 'what' and 'who' -related systems may lend themselves more readily to a set of cultural or scale-of-fishery circumstances that encompass broader ecosystem considerations and prove to be successful from a sustainability perspective, as demonstrated by Gutiérrez *et al.* (2011).

Fishery-specific level

The FAO (1997) classifies the options for regulating, i.e. managing, at the fishery level as technical measures, input controls and output controls. The catch-all term "technical measures", according to the FAO, includes not only gear restrictions, but also area (spatial) and time (temporal) measures. But here, at the fishery-specific level, in MSC vernacular, the terminology can be taken to have the same meaning and intent as rules, tools and measures which may combine into a partial or full strategy designed to ensure a fishery does not pose a risk of serious or irreversible harm to habitat types (MSC, 2011a).

For the purposes of this report, the table below (Table 1) makes more distinctions than the FAO classification because, as will be demonstrated, some fishery-specific controls are particularly relevant to the issues of managing and/or mitigating the benthic impacts of fishing. Included in the report is a classification that recognises that some or all of the measures listed may constitute ecological risk management measures or strategies, thus being classified as precautionary measures.

Table 1. Classifying fishery-specific management tools with a limited selection of examples

Technical measures	Input controls	Output controls	Spatial controls	Temporal controls
Gear specification	Fishing effort restrictions	Total allowable catch	Closed areas / No fishing zones	Seasonal protection
Outright prohibition	Limited entry		Protection of spawning grounds	Opening / closing season according to sensitive life cycle stages
Exclusion of specific types	Vessel numbers		Protection of juvenile or larval grounds	
Configuration, e.g. mesh size, head rope length	Fleet capacity		Protection of migratory routes	
Operation or deployment rules	Total gear deployment, e.g. total pot numbers, combined total head rope length		No trawl zones	
Subsidiary devices	Time limits on fishing	Catch shares	TURFs (Territorial Use Rights)	Rotational controls
Bycatch reduction devices	Days at sea	Individual transferable quotas		Rolling opening and closings according to gear used
Escape panels	Soak times	Community quotas		
Tory poles				

Technical measures	Input controls	Output controls	Spatial controls	Temporal controls
Minimum size, maturity or sex restrictions Landing size Berried females	Individual effort quotas	Discarding and catch landing rules	Critical or essential habitat protection	\
	Vessel size or length <i>Vessel capacity</i> <i>e.g. gross weight tonnage; engine capacity kWt</i>	Bycatch limits <i>Proportional to total catch</i> <i>Absolute limits</i> <i>Biologically based limits</i>	Marine Protected Areas Marine Managed Areas <i>Multiple-use areas</i>	
Precautionary measures		Ecological risk management		

MSC Principle 2, Habitat Management Performance Indicator – other measures, partial strategies and strategies

In the [previous paper](#) we gave extensive information about gear-related technical measures, such as gear modification. In this section of our report we focused on giving best practice examples of non-technological measures, partial strategies and strategies that may have relevance to the MSC performance indicator and scoring guideposts for habitat management. Table 2 below shows the Habitat Management performance indicator at the time of writing our original report (MSC, 2011a) in order to provide a framework for considering examples of best practice of management and/or mitigation actions from various regions of the world.

Following the standard format for all MSC performance indicators, the table shows the Habitat Management performance indicator and its constituent scoring issues, each of which must be examined and scored according to the characteristics described in the scoring guideposts.

Table 2. MSC Habitat Management Performance Indicator and Scoring Guideposts (SG)

Performance Indicator (PI)	Scoring Issues (SG)	SG60	SG80	SG100
<p>Management strategy 2.4.2</p> <p>There is a strategy in place that is designed to ensure the fishery does not pose a risk of serious or irreversible harm to habitat types.</p>	a. Management strategy in place	There are measures in place, if necessary, that are expected to achieve the Habitat Outcome 80 level of performance.	There is a partial strategy in place, if necessary, that is expected to achieve the Habitat Outcome 80 level of performance or above.	There is a strategy in place for managing the impact of the fishery on habitat types.
	b. Management strategy evaluation	The measures are considered likely to work, based on plausible argument (e.g. general experience, theory or comparison with similar fisheries/habitats).	There is some objective basis for confidence that the partial strategy will work, based on information directly about the fishery and/or habitats involved.	Testing supports high confidence that the strategy will work, based on information directly about the fishery and/or habitats involved.
	c. Management strategy implementation		There is some evidence that the partial strategy is being implemented successfully.	There is clear evidence that the strategy is being implemented successfully.
	d. Management strategy evidence of success			There is some evidence that the strategy is achieving its objective.

To give further clarity and context for considering best practice management/mitigation action, the MSC guidance makes the following distinctions between the meanings of “measures”, “partial strategy” and “strategy” as follows (MSC, 2011b):

“These performance indicators (PI) intend to assess the arrangements that are in place to manage the impact that a fishery has on the component. The Scoring Guideposts (SGs) contain a mixture of requirements for either measures to be in place or strategies. To clarify the difference:

- a. “**Measures**” are individual actions or tools that may be in place either explicitly to manage impacts on the component or coincidentally, being designed primarily to manage impacts on another component, indirectly contribute to management of the component under

assessment. For example, the closure of an area may have primarily been put in place to avoid the catch of juvenile target species and enhance target species sustainability. It may also have a beneficial effect on the bycatch of sensitive species such as other juvenile finfish. If such a measure were effective in assisting the fishery to achieve the SG80 level for the Bycatch Species Outcome PI then this could be considered as a management measure under the Bycatch Species Management Strategy PI.

- b. A “**strategy**” represents a cohesive and strategic arrangement which may comprise one or more measures, an understanding of how it/they work to achieve an outcome and which should be designed to manage impact on that component specifically. A strategy needs to be appropriate to the scale, intensity and cultural context of the fishery, and could include voluntary or customary arrangements, agreements or practices, codes of practice (if they can be demonstrated to be working). A strategy should contain mechanisms for the modification fishing practices in the light of the identification of unacceptable impacts.
- c. A “**partial strategy**” represents a cohesive arrangement which may comprise one or more measures, an understanding of how it/they work to achieve an outcome and an awareness of the need to change the measures should they cease to be effective. It may not have been designed to manage the impact on that component specifically.

Examples of ‘best practice’ from around the world

A limited selection of examples are presented as the kinds of non-technical practices that might be considered as measures, partial or full strategies under the MSC’s Habitat Management PI. Table 3 summarises information by ocean region, with reference to the classification of fisheries management systems described in Section 3 and the terminology referenced above about MSC’s Management PIs. Fisheries approaches (at system and fishery-specific levels) presented here are intended to highlight practices in relation to precautionary, protective or restorative management and/or mitigation measures.

Table 3. Summary of best practice examples

Region	Systems level – what	Systems level – who	Fishery-specific controls, rules or tools for habitat management	Potential rating under PI Habitat Management’s SG	References
Arctic, Atlantic and Pacific Oceans: Canada – policy – impacts of fishing on sensitive habitats e.g. 3Ps cod fishery	Future management plans: ecosystem-based approach to fisheries management Pre-2009 plans: single/multi-species approach with some ecosystem consideration	Co-management (consultative)	Ecological Risk Analysis Variety of input controls possible Ecological risk management, precaution Monitoring and evaluation	After policy fully implemented: strategy Until policy is implemented more fully: measures or partial strategy	DFO, 2009a DFO, 2011
Atlantic Ocean: European Union – protection of vulnerable high seas habitats from adverse impacts of fishing	Common Fisheries Policy Regulation which individual Member States have to implement	Co-management (consultative)	Measures to protect high seas deep water vulnerable seamounts and other habitat features	Measures – if Member States implement regulation	CEC, 2008
Atlantic Ocean: USA – Georges Bank groundfish and sea scallop fisheries	Ecosystem-based approach to fisheries management (future direction) Multi-species approach	Co-management (consultative)	Closed areas prohibiting groundfish catching fishing gear (trawls, scallop dredges, gillnets, hook fishing) Habitat Area of Particular Concern designation Enforcement, Vessel Monitoring Systems, high sanctions	Partial strategy	Murawski <i>et al.</i> 2000

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Region	Systems level – what	Systems level – who	Fishery-specific controls, rules or tools for habitat management	Potential rating under Habitat Management PISG	References
Pacific Ocean: USA – west coast groundfish fisheries	Ecosystem-based approach to fisheries management (future direction) Note that NMFS (2010) suggests habitat-related assessment and management implementation to date have been more like a single species approach	Co-management (consultative)	Essential Fish Habitat environmental impact assessments for fishery management plans Effort reduction Spatial controls, including trawl closures to protect essential fish habitat NGO trawl permit buy-out & lease back for less damaging fishing methods (incentives for sustainable fishing)	If new habitat science approach funded properly: strategy Partial strategy	Nielsen & Gjertsen, 2010 NMFS, 2010
Atlantic Ocean, Pacific Ocean: Various countries – marine managed areas (MMAs) Brazil US (Hawaii) Republic of Palau	Ecosystem-based management	Co-management – community-based management	Dog snapper abundance in tropical waters off Brazil is enhanced by MMA protection of mosaic/patchwork of mangrove, seagrass & coral habitats Fish Replenishment Areas (no-take areas) are another form of MMA on Hawaii's Big Island. Rigorous enforcement and public communication boosted populations for yellow tang fishery. Republic of Palau – science-based initiative leads to community-based processes and protection measures, enhanced reef health and fisheries resources	Partial strategy – strategy	Kaufman & Tschirky, 2010 Nielsen & Gjertsen, 2010 IAN (2011)

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Region	Systems level – what	Systems level – who	Fishery-specific controls, rules or tools for habitat management	Potential rating under Habitat Management PISG	References
Pacific Ocean: New Zealand – whitefish (hoki, ling, hake & southern blue whiting) trawl fisheries	Single-species approach, with ecosystem consideration	Co-management (co-operative)	Evolving approach, bringing MPAs and habitat research of the effects of fishing into consideration. Benthic Protection Zones developed for conservation purposes in consultation with fishers	Partial strategy	
Region	Systems level – what	Systems level – who	Fishery-specific controls, rules or tools for habitat management	Potential rating under Habitat Management PISG	References
Pacific Ocean, Southern Ocean, Indian Ocean: Australia – multiple Commonwealth (Federally) managed fisheries e.g. Bass Strait scallop fishery	Ecosystem-based fisheries management approach	Co-management (consultative)	Marine bioregional planning Ecological risk assessments and management for fish species Ecological risk assessments and risk management planned, but not currently able to deal quantitatively with habitats or ecosystems Precautionary management using closed areas and MPAs Able to use full suite of technical measures, input & output controls Habitat mapping for fisheries and conservation goals	Partial strategy – full strategy if able to conduct Ecological Risk Management for habitats	AFMA, 2009

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Region	Systems level – what	Systems level – who	Fishery-specific controls, rules or tools for habitat management	Potential rating under Habitat Management PISG	References
Indian Ocean: Western Australia – multiple State managed fisheries	Ecosystem-based fisheries management, with other sectoral management and protection considerations (not quite full ecosystem-based management)	Co-management (consultative)	Fish Habitat Protection Areas Permanent trawl closure Input controls – individual transferable effort; gear restrictions; area closures Ecological Risk Assessments Monitoring, Assessment & Research	Strategy	DOF, 2011 Sainsbury, 1987 Sainsbury <i>et al.</i> 1993 Turner <i>et al.</i> 1999
Indian Ocean: Kerala State, India	State regulation – single species approach		Trawl ban in inshore waters during monsoon months	Measures	Aswathy & Sathiadhas, 2006 FISHNET, 2011 Infochange, 2011

Measures

European Union

In 2008, the Council of Ministers signed into force Regulation (EC) No. 734/2008 on the protection of vulnerable marine ecosystems in the high seas from the adverse impacts of bottom fishing gears. This regulation requires EU Member States to implement its provisions on their own flagged vessels. The provisions, which require special licenses to be granted to fish in the high seas to fishers who submit detailed fishing plans and are willing to submit to compliance and data gathering measures. Member State are to evaluate proposed plans by assessing the risks to potentially vulnerable marine ecosystems and habitats. On the surface the provisions appear as they might work to protect and/or manage impacts upon deep water habitats, assuming Member States implement and enforce them.

As a fisheries management instrument, it might be possible for certification bodies to acknowledge that it may constitute a 'measure' under the Habitat Management performance indicator and therefore score it greater than 60. The rationale for this is that the regulation constitutes a single tool or action, rather than a group of tools put together into a partial or full strategy to manage the fishing impacts of benthic habitats. Thus, if such a measure contributed to ensuring that fishing was highly unlikely to reduce habitat structure and function to a point where there would be serious or irreversible harm (i.e. a measure that is expected to meet the 80 scoring level of the Habitat Outcome PI), then a score of greater than 60 would be justified. However, unless it is indeed implemented through licensing provisions or Member State regulations, and there is some evidence of applying it, the 'score' value of the regulation is highly likely to be diminished.

India

Every year for about a decade, during the monsoon months (June to August), the Kerala State government implements a ban on bottom trawling in inshore waters in order to protect juvenile and spawning habitat for fish and invertebrate species (Aswathy & Sathiadhas, 2006; Infochange, 2011). The State's fisheries management system is mainly geared towards social objectives, particularly those that develop fisheries resources, alleviate poverty and give equitable access to communities to fisheries resources and markets (FISHNET, 2011). There is one objective which refers to sustainable use of fisheries (ibid). Individual fishery rules are difficult to track down on the internet, however, the trawl closure during the monsoon months is widely publicised by local newspapers, TV stations and increasingly online media and is often linked to the concept of habitat protection (Infochange, 2011).

Looking at the closure from the perspective of the MSC standard for the Habitat Management performance indicator, such a management arrangement could be considered both temporal and spatial and could, on closer examination, prove to be rated as a 'measure' which offers some management and/or mitigation of trawl impacts on benthic habitat. The rationale for determining that it could be rated as a measure worthy of a score greater than 60, but less than the 80 awarded for partial strategies (cf Table 2), is that it seems to stand in isolation as a management tool and seems also to be principally aimed at protecting fish in the spawning season – yet, in order to do so, spawning habitat appears to need protecting from trawling during these monsoonal periods. But, as with all the examples presented in this chapter, without much deeper analysis it is educated speculation about how well such a single tool or action might meet the MSC Habitat Management performance indicator.

The above two examples demonstrate how single tools or actions might be considered 'measures' under the MSC Habitat Management performance indicator and could justifiably be used to determine that management seeks implicitly or explicitly to make sure fishing is high unlikely to reduce habitat structure and function to a point where there would be serious or irreversible harm.

Partial strategies

New Zealand

At a system level:

New Zealand's *Fisheries Act, 1996* is the principal instrument guiding fisheries management in New Zealand. The Ministry responsible for managing NZ's fisheries also has substantial obligations to Maori under various Acts and the Treaty of Waitangi. The main instrument for managing fisheries is the output control that is the Quota Management System, which independently manages 636 separate stocks in quota management areas.

The Fisheries Act requires benthic resources to be managed. In 2009, the Ministry published a statement of intent about fisheries management into the future. One of the strands of this stated intention is to not only manage marine benthic resources, but also to protect a representative range of marine habitats in New Zealand ecosystems from the adverse impacts of fishing. This intention complements the 2006 policy initiative which seeks to develop a representative system of marine protected areas. Similarly, there is a complementary intent to devise a "Habitat Standard" which will define how much of each habitat will remain free of damage from fishing in order to ensure habitats function and contribute effectively to fish production and marine ecosystem health. (NZ, 2010) Each of these initiatives are seen as part of the government's "*strategy for managing the environmental effects of fishing*" a draft of which was developed in 2006-07 and aims to implement an ecosystem approach to fisheries (NZ, 2007).

Fishery-system level:

Deepwater habitats in the demersal whitefish fisheries for hoki, ling, hake and southern blue whiting are now classified as "Benthic Protection Areas" (BPAs). These areas protect a range of deep water seamounts from the impacts of trawling and dredging. Around 32 percent of deep water habitats within NZ's waters are said to be protected (NZ, 2010). A total of 17 areas cover about 1.1 million square kilometres of seabed, protecting 52% of seamounts and 88% of active hydrothermal vents from impacts of fishing.

Research emerging from the above fisheries in connection with MSC certification (in the case of hoki since 2001, and in the case of the other species if certified) and the habitat performance indicators may reveal whether the BPAs are achieving fishery-management related outcomes, or serve as more general conservation measures. However, a partial strategy score (or higher) is probably warranted in the hoki and other demersal whitefish fisheries because of the broader management context noted above, as well as fishery-specific research, monitoring and mitigation of benthic impacts of fishing in demersal whitefish fisheries.

For example, in the hoki and other whitefish demersal fisheries, the fishery footprint across the whole of the country's Exclusive Economic Zone (EEZ) has been examined and the spatial scale and relative intensity of benthic impacts for the major fisheries have been documented (Punt *et al.* 2011). This extensive research and the fact of the BPAs enabled certifiers to close out habitat-related conditions (*ibid*). The research will also contribute to future consideration of any benthic management or protection measures. So, the fact that New Zealand has system level policies articulating a strategy, specific measures in place, and that there is an ongoing programme of science and monitoring albeit for conservation purposes, with some fishery-specific research contributing to the information upon which management decisions are made, then a partial strategy seems justified. Until dedicated research and monitoring helps clarify the interaction between the BPAs and habitat health, scoring 100 under the Habitat Management performance indicator does not appear to be warranted.

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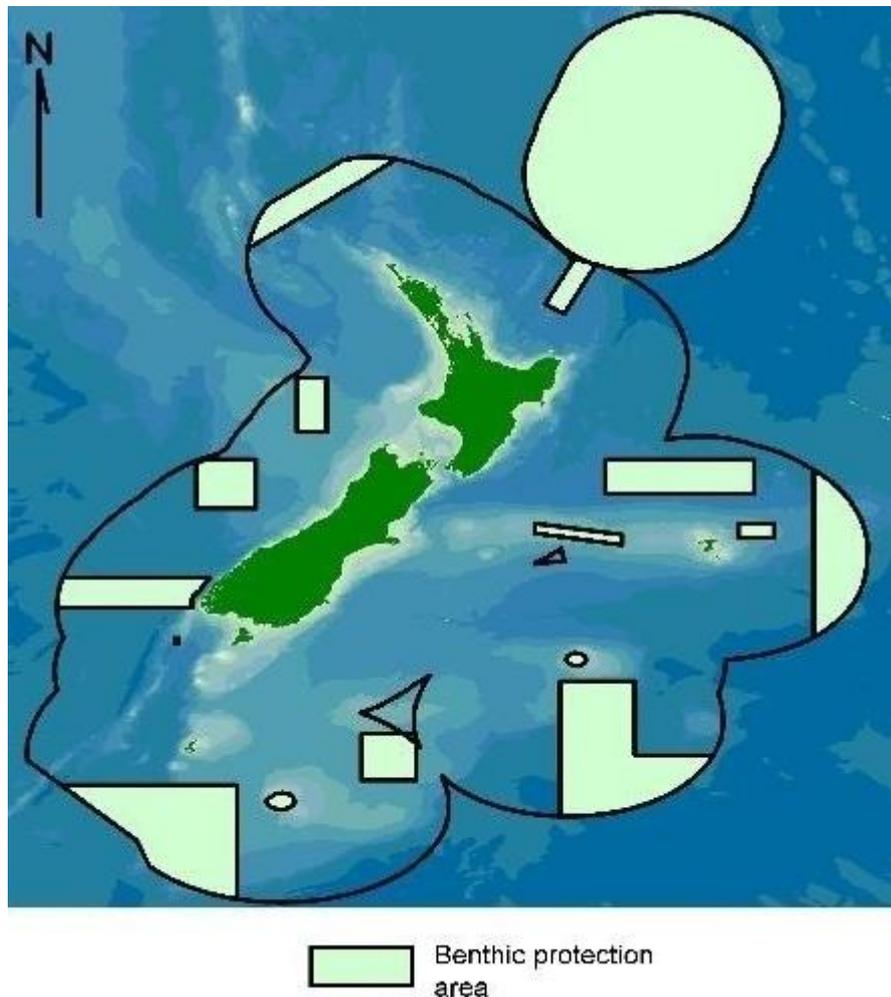


Figure 1: New Zealand's Benthic Protection Areas (Source: NZ, 2010 - ©CC BY 3.0 NZ)

Various Tropical Countries – Brazil, US (Hawaii), Palau

Marine Managed Areas (MMAs): The international non-governmental organisation Conservation International, along with other NGOs, government, university and scientific organisations have spent decades and millions of US dollars working in tropical regions to help developing countries improve their management of marine ecosystems. Their definition of an MMA is often interchangeable with what is commonly understood to be a Marine Protected Area (MPA) – an MMA is a multiple-use ocean zone in which certain human activities may be allowed, but other activities may be prohibited or restricted. All activities are adaptively managed, many are backed with enforcement or sanctions, incentives, and monitoring and evaluation. Conservation International's objectives for implementing MMAs are to protect biodiversity and increase resource yields for local communities, including fishers (Nielsen & Gjertsen, 2010).

Case studies reveal the habitat management measures and partial strategies that go beyond simply reducing the benthic impacts of fishing, but are designed to ensure a mosaic of healthy, connected habitats are left intact, thus providing healthy ecosystems in which fisheries resources can thrive (Kaufman & Tschirky, 2010). For example, in Brazil the connection between a patchwork of mangroves, seagrass beds and coral reefs, in inshore, inner shelf and mid-shelf habitats was recognised as important for dog snapper fisheries. Co-management of multiple MMA sites by fishers, scientists, NGO and local government representatives ensured habitats were protected and abundance of snapper increased (ibid). Similarly, on Hawaii's Big Island, the implementation of Fish Replenishment Areas (another term for no-take zones and a variation on the MMA theme), coupled with extensive public communication and rigorous enforcement led to populations of yellow tang increasing and supporting the local fishery for this species (Friedlander *et al.* 2014).

These examples demonstrate that strategies and partial strategies involving preventative, precautionary and/or restorative measures for benthic habitats can result in improved outcomes for fisheries. Thus forming an integral part of ecosystem-based management, rather than managing for, or mitigating the after effects and impacts of bottom-impacting fishing gear with single measures or actions. This means that a holistic, strategic approach is being taken, particularly in some areas where data may be deficient, and hence the rationale for determining that a score of 80 or higher may be warranted under the Habitat Management performance indicator.

In the Republic of Palau, land-based activities have been negatively impacting coral reef health and subsequent fishery resources. Community-based processes involving traditional leaders and villagers and supported by local NGOs, US scientists and NGO representatives, and involving local government, resulted in science-based solutions to activities that were impacting coral reef habitats and habitat-related local fisheries resources (IAN, 2011).

Partial strategies involving habitat protection to enhance coral reef health had knock-on effects for fishery health. The main aim of the science-based efforts involving community-based processes was to meet conservation objectives, but the subsequent boost to fishery resources suggests the measures and partial strategies served to reduce impacts on benthic habitats (if not fishing-related impacts, then other human impacts).

Gutiérrez *et al.* (2011) were able to demonstrate in their study that protected areas were one of the key factors in predicting co-management success in fisheries. However, their value in contributing to successful fisheries management depends upon local community engagement, cohesive social organisations, appropriate incentives and spatial considerations (e.g. well-defined areas and resource life history associations) (ibid).

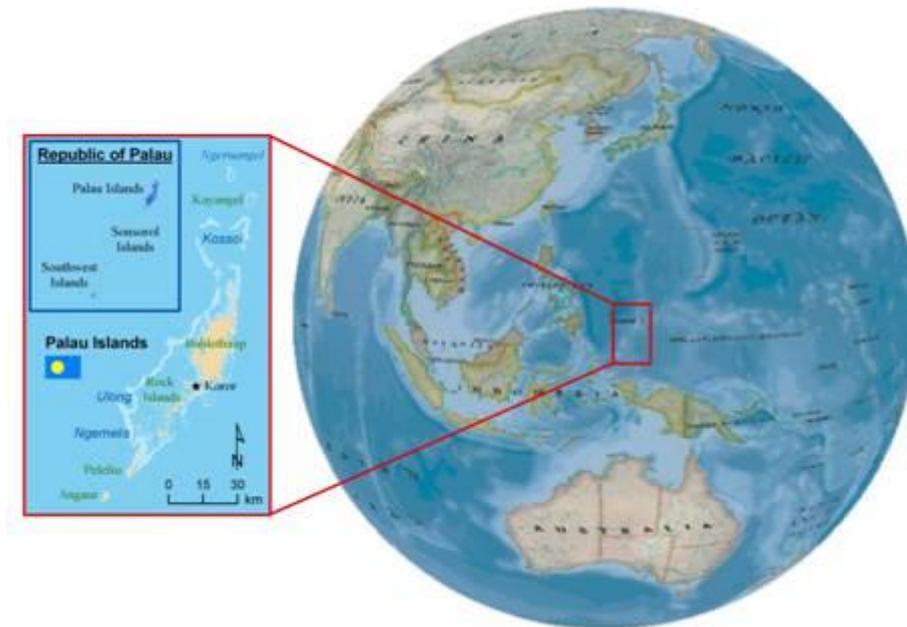


Figure 2: Source - NOAA Biogeography Branch

Strategies

Commonwealth of Australia

At a system level:

At a Federal level Australia's fisheries are managed by a statutory authority with a board of Commissioners delegated by the government to make fisheries management decisions under the *Fisheries Management Act, 1991*. The Australian Fisheries Management Authority (AFMA) uses an ecosystem-based approach to fisheries management in a co-management (consultative) framework. Comprehensive fisheries management plans are developed for all major fisheries. Statutory fishing rights (based on input or output controls) are allocated to individuals. Compliance and enforcement strategies are planned according to fishery dynamics. As are fishery assessment, monitoring and research strategies. All fisheries under Federal jurisdiction undergo ecological risk assessments and have ecological risk management plans drawn up to manage risks and uncertainties to the key components of ecosystems: target species, retained and bycatch species, habitats and ecosystems (see Wayte *et al.* 2004). The risk assessment process is very similar to the MSC's Risk Based Framework (RBF) as its developers were some of the same people who brought their expertise to the MSC process. The development of risk management strategies in AFMA-managed fisheries is determined by the outcomes of the ERA process which indicate the high, medium and low risk species according to species and fishery dynamics (Figure 3).

Australian fisheries are also governed by the *Environment Protection and Biodiversity Conservation Act, 1999* which requires an assessment of sustainability based upon criteria that originated from the MSC's own Principles and Criteria for Sustainable Fishing. All fisheries managed by AFMA have now undergone such assessments and re-assessments.

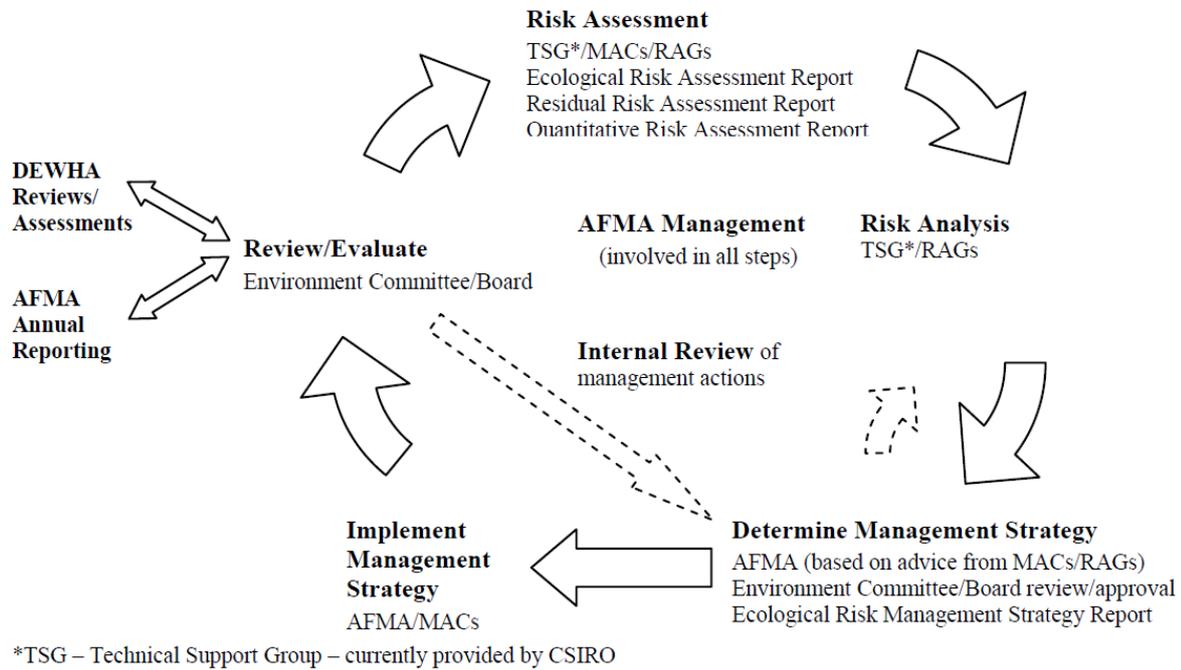


Figure 3: Australia's (Federal level) approach to Ecological Risk Management in fisheries. Source: AFMA, 2009

Australia also has an Oceans Policy which provides a framework for implementing a plan for marine bioregionalisation and the creation of a network of representative Marine Protected Areas at a national level. The first network of MPAs, called Commonwealth Marine Reserves, was declared in the Federal waters of Australia's southeast region in 2007 (Figure 4). This bioregion was chosen because it is a region attributed with the highest biodiversity conservation values and yet is exposed to the greatest threats, i.e. commercial fishing (Williams *et al.* 2009).

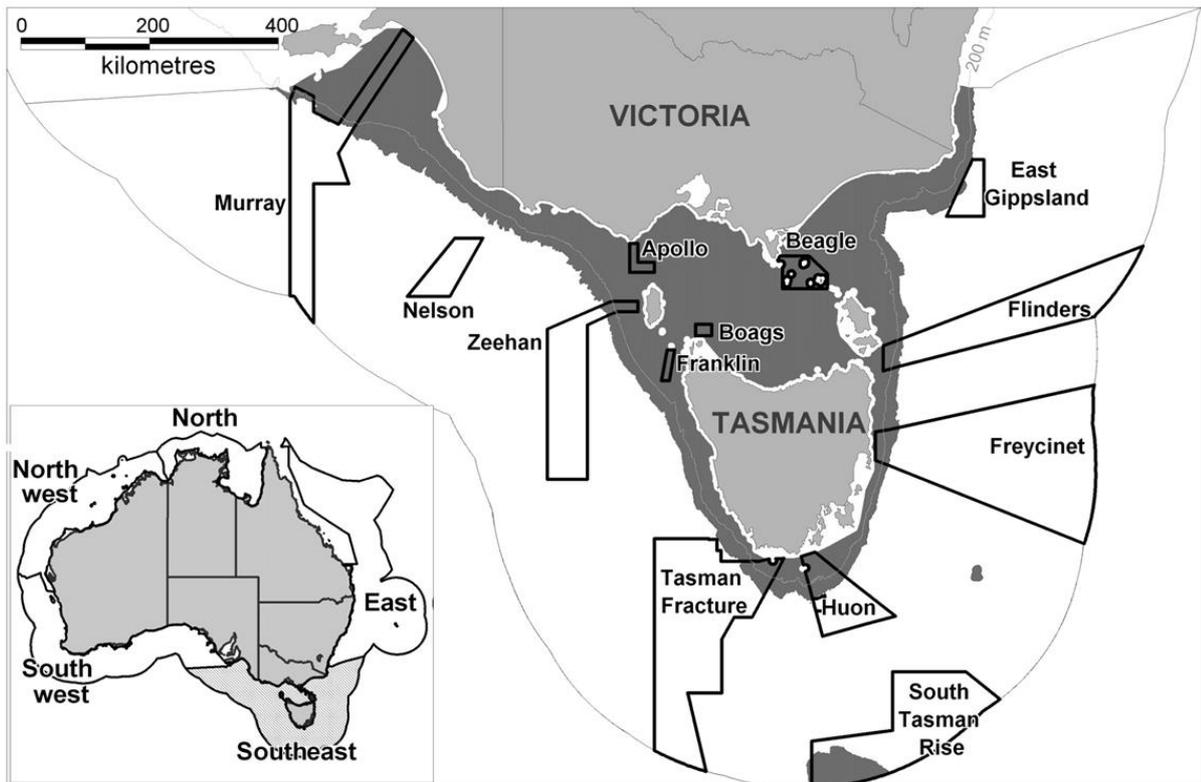


Figure 4: Australia's southeast network of Commonwealth Marine Reserves (Williams *et al.* 2009)

Fishery-system level:

In order to explore best practices under this fisheries management system, one fishery with known impacts upon habitats was selected: the Bass Strait Scallop Fishery in which scallop dredges are used to harvest resources. The Bass Strait is located between the state of Victoria on the Australian mainland and the island state of Tasmania (see Figure 3 above). According to the fishery's Ecological Risk Management report, an ecological risk management strategy specifically for habitats was deferred due to limitations in the ecological risk assessment methodology (AFMA, 2009). Despite this, the fishery explicitly operates a comprehensive spatial harvest strategy which involves closing the majority of the area of the fishery with the exception of specific areas opening on a rotational basis (*ibid*). In 2009 this resulted in a fished area equating to only about 0.2% of the potential fishable area actually dredged (*ibid*). By enabling fishers to target high scallop density areas by using adaptive management, impacts on habitats, other species, smaller scallops and other ecosystem components was minimised. The spatial management harvest strategy has the secondary effect of protecting benthic communities and habitat (*ibid*).

As scallop fishery managers acknowledge, their management strategy has the secondary effect of protecting habitat. It is unclear whether there is an intention to study habitats and the effect of the harvest strategy upon them directly. It is essentially educated guesswork and seems to work as a precautionary strategy. When one takes into account the system-level legislative and policy framework, the research and monitoring that went into implementing the network of Commonwealth Marine Reserves, three of which exist in Bass Strait itself, an assessment of the management against the MSC's Habitat Management performance indicator might result in a score of over 80. However, until focused research reveals that their harvest strategy does serve to avoid serious or irreversible harm to habitats, it might rate as a 'partial strategy' under MSC's habitat management performance indicator, rather than a 'strategy', thus not quite scoring the perfect 100.

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Western Australia

At a system level:

The Western Australian State government has adopted an ecosystem-based fisheries management system. Bioregional management areas are used to protect biodiversity and to manage fishing and ecotourism. The legal framework governing how commercial, recreational and indigenous use of fisheries resources are managed is provided by the Western Australia *Fish Resources Management Act, 1994*. The risks to so-called ecological assets are assessed, including ecosystems, habitats and resources. Specific ecological risk assessments are conducted on fisheries resources, the results of which are presented in Integrated Fisheries Management Reports under an Integrated Fisheries Management initiative which takes account of a bioregion's fish stocks in protected areas within all allocation processes (DOF, 2011).

The Act empowers decision-makers to create "Fish Habitat Protection Areas", several of which have been created in the West Coast Bioregion to meet conservation objectives not strictly related to fisheries management objectives. According to DOF (2011), extensive trawl closures enacted in the 1970s and 1980s still exist to protect seagrass and reef habitats, known to be important fish habitat, from the physical impact of fishing. The WA fisheries department also reports that around 41% of the continental shelf in the North Coast Bioregion effectively acts as a marine protected area with an IUCN level IV classification (managed areas which seek to maintain, conserve and restore species and habitats, Dudley 2008) (DOF, 2011).

Fishery-specific level:

In Western Australia's North Coast Bioregion, extensive trawl closures have also been introduced as part of the management of tropical finfish resources (e.g. snappers and emperors), while some trawling is allowed for prawns (Figure 4 and Figure 5).

Decisions such as those to continue with extensive trawl closures along vast stretches of coastline and the continental shelf may be supported, if not also informed, by research results. For example, ecosystem and habitat research on Western Australia's north west continental shelf during the 1980s and 1990s demonstrated that a five year trawl closure led to increased populations of commercially important species like snappers and emperors, but that recovery of the epibenthic habitat structure was slow and researchers postulated that after heavy trawling it may take up to 20 years to fully recover (Sainsbury, 1987 and Sainsbury *et al.* 1993, cited in Turner *et al.* 1999). Every four-five years, trawl, trap and closed management areas are surveyed to provide ongoing information about the ecologically sustainable development of the ecosystem (DOF, 2011), thus providing ongoing monitoring which would help determine whether habitat management is achieving its objectives.

It may also be possible, from the sources cited above (Sainsbury, 1987; Sainsbury *et al.* 1993; DOF, 2011), to infer that the protection of benthic habitat from the impacts of trawling has had significant effects on the health of fish stocks, the habitats and other components of managed ecosystems. In a finfish fishery assessment against the MSC's Habitat Management performance indicator, three aspects of management could inform such a fishery's score: the long-standing approach, under the systemic framework, to directly protect benthic habitat in the fishery; any published results of peer reviewed research that make the link between management action and positive habitat status outcomes; and evidence of modification of fishing practices or management consistent with those results. These may all add up to a 'strategy' for considering habitat directly under the fishery's management approach, as defined in the MSC Certification Requirements. The combination of other fishery management measures for finfish in the bioregion (e.g. area closures, gear restrictions and individual transferable effort quotas (DOF, 2011) could also contribute to the scoring of the Habitat Management PI as a 'strategy' and awarding it 100.

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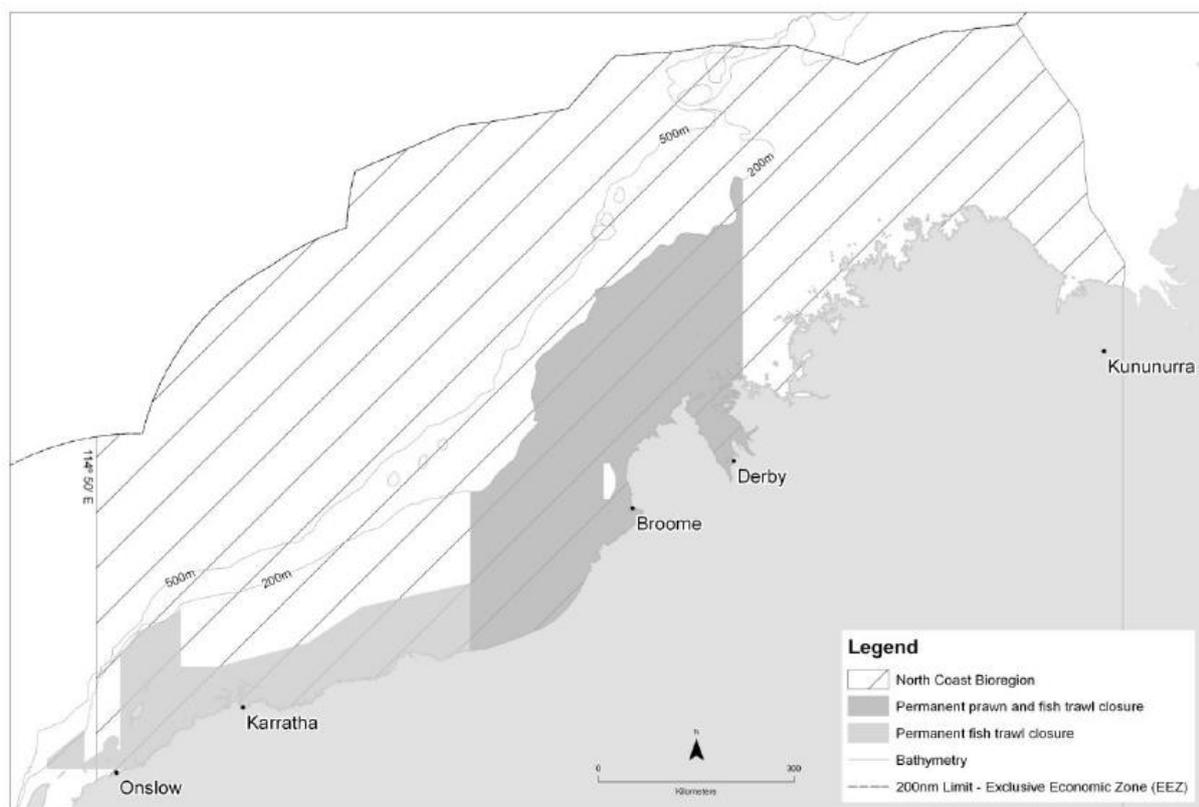


Figure 5: Trawl exclusion zones in Western Australia's North Coast Bioregion (DOF, 2011)

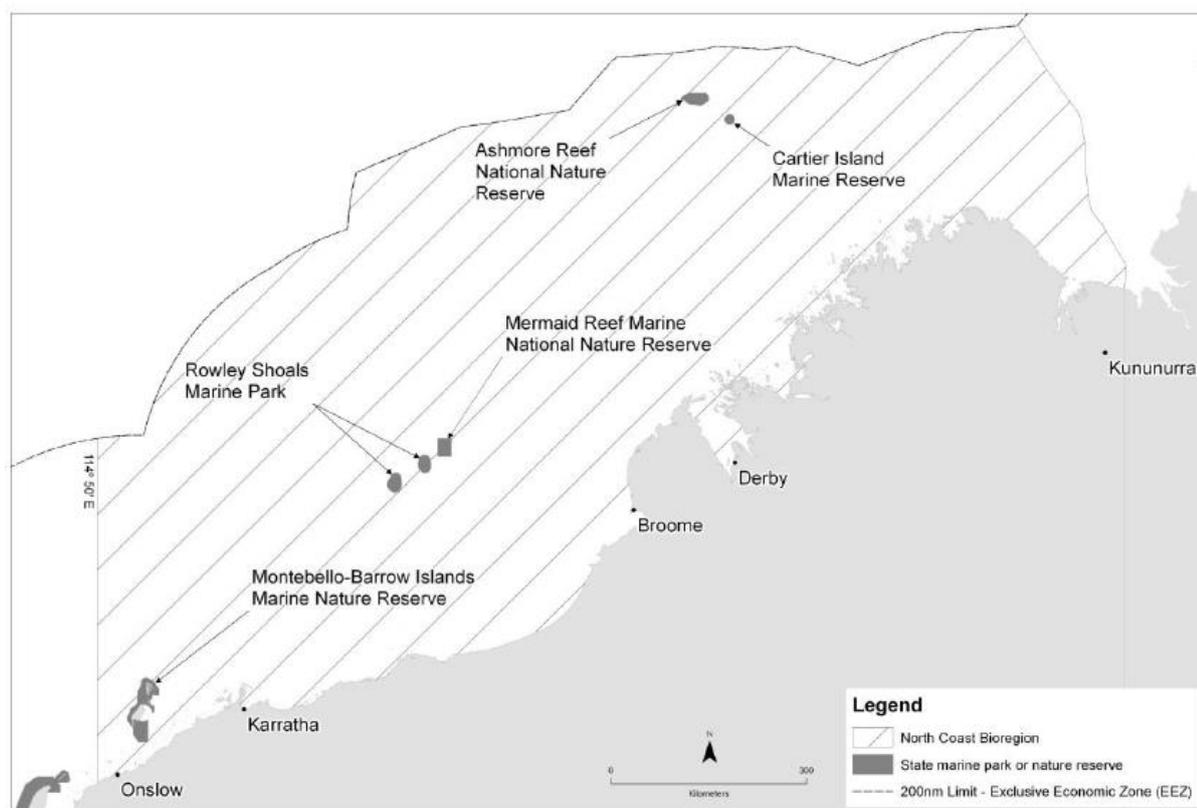


Figure 6: Existing and proposed fish habitat protection zones, Western Australia's North Coast Bioregion (DOF, 2011)

Canada

At a system level:

In 2009, Canada's Department of Fisheries and Oceans implemented a policy framework for managing the impacts of fishing on sensitive habitats by all commercial, recreational and Aboriginal fishing activity. The policy seeks to: mitigate impacts where it is biologically justified and cost effective; and provide enhanced protection to marine habitats that are particularly sensitive (DFO, 2011). The policy sits under the legal and policy framework provided by Canada's *Fisheries Act*, *Oceans Act* and *Species at Risk Act* and is said to be guided by international instruments governing both fisheries and the oceans (e.g. UNCLOS, CBD and the Fish Stocks Agreement) (ibid). The *Oceans Act* also provided the framework for the designation of a network of Marine Protected Areas in Canada's EEZ.

Under the sensitive habitats policy, "frontier fishing areas", i.e., those parts of Canada's EEZ that have not previously been fished, can be subject to higher levels of precautionary management in relation to sensitive habitats than might be applied to "historically fished areas" (although it is noted that the degree of uncertainty in these areas will determine the levels of "risk aversion" applied) (DFO, 2011).

The policy set out processes for managers and scientists to follow for:

- Assembling and collecting data and information about benthic habitat, communities and species.
- Assessing data and information to determine the ecological and biological significance of benthic features and risks of serious or irreversible harm fishing activity may cause.
- Making appropriate management decisions using an ecosystem approach and precaution.

To avoid serious or irreversible harm to sensitive benthic habitat, species and communities and otherwise address impacts to them, Canada's policy uses the following process:

- Assemble and map existing data and information that would help determine the extent and location of benthic habitat types, features, communities and species; including whether the benthic features (communities, species and habitat) situated in areas where fishing activities are occurring or being proposed are important from an ecological and biological perspective.
- Assemble and map existing information and data on the fishing activity.
- Based on all available information, and using the Ecological Risk Analysis Framework, assess the risk that the activity is likely to cause harm to the benthic habitat, communities and species, and particularly if such harm is likely to be serious or irreversible.
- Determine whether management measures are needed, and implement such management measures.
- Monitor and evaluate the effectiveness of the management measure and determine whether changes are required to the management measures following this evaluation. (DFO, 2011)

In addition to the newly developed habitats policy, under Canada's *Fisheries Act*, action by the Department of Fisheries and Oceans as well as voluntary industry action has resulted in the introduction of closed marine areas that are managed to benefit benthic environments. The use of bottom-contacting fishing gear is prohibited or restricted in order to conserve or manage benthic species, habitat or biodiversity, particularly in fragile marine areas (DFO, 2009a) (Figure 6).

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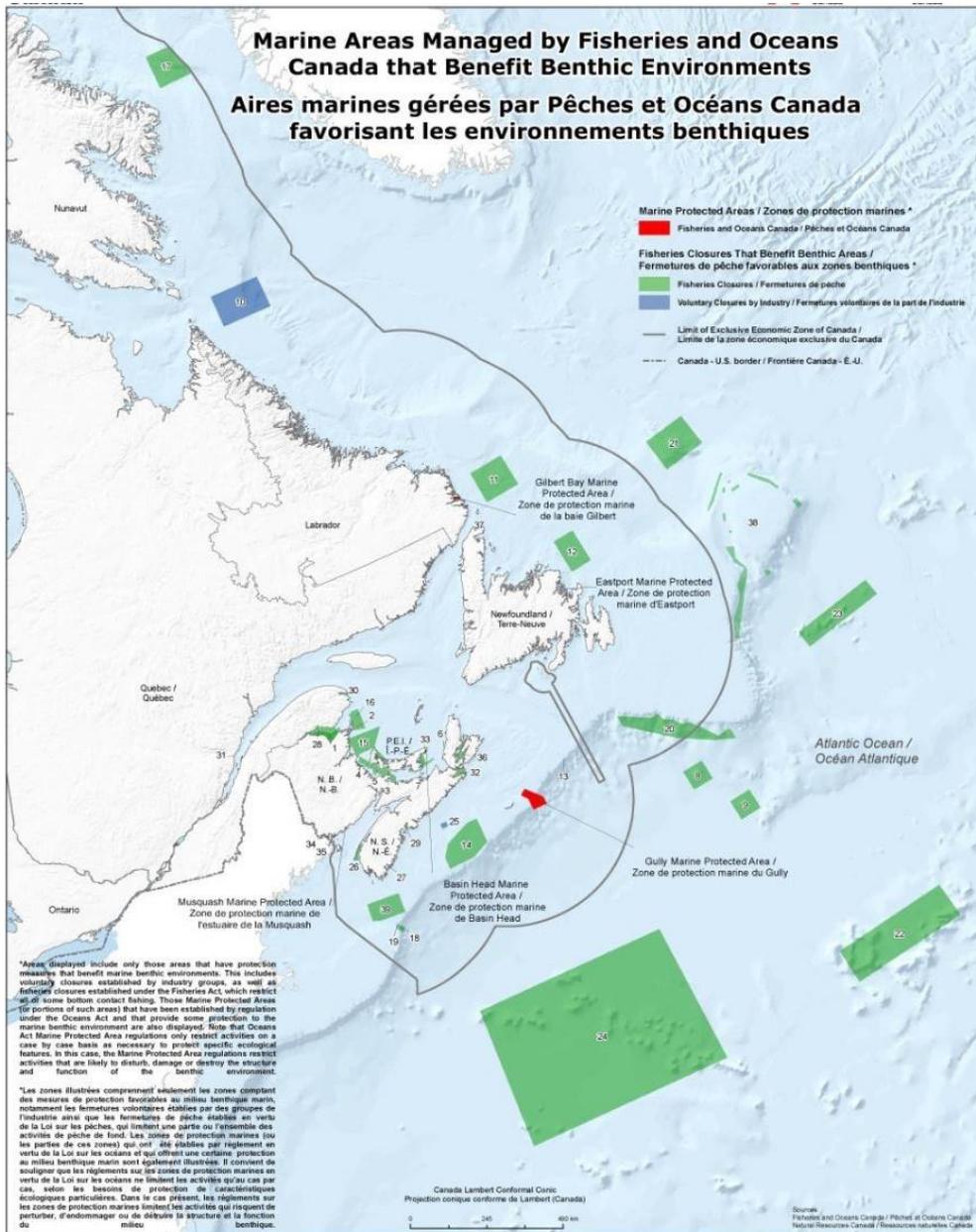


Figure 7: East coast of Canada - a selection of fishing closures to protect benthic environments (DFO, 2009a; <http://open.canada.ca/en/open-government-licence-canada>)

Fishery-specific level:

In both Canada's "frontier fishing areas" and "historically fished areas", management measures may include:

- Restrictions, substitution of another type of gear or modification of gears to reduce contact with the benthos and seafloor.
- Reduced effort.
- Spatial management of effort (taking into account the spatial distribution of benthic habitat and communities).
- Establishment of partial or total time and area closures where use of certain or all gear types are not permitted.
- Closures to all fishing.
- Where fishing has been permitted in areas where sensitive benthic habitats or species may be present, all activities will, by necessity, be subject to complete monitoring, control and surveillance. This will include vessel monitoring and at sea observer requirements.
- High levels of monitoring, control and surveillance, including enhanced data collection and reporting, vessel monitoring and at sea observer requirements (DFO, 2011).

It is unclear from this desktop review whether DFO managers have applied the policy to specific fisheries or re-examined existing Integrated Fisheries Management Plans. Although a search of the DFO website revealed Integrated Fisheries Management Plans for several species, most of them were implemented before the policy was finalised. Despite this, choosing a fishery at random (the "3Ps Cod Fishery" – Figure 7), an examination of the management plan reveals some use of spatial and input controls to manage fishing activity and potentially its impact on habitat (DFO, 2009b). For example, there are rules protecting inshore grounds from mobile gear and closed areas protecting cold water corals (ibid). However, habitat is not explicitly mentioned in the plan's objectives and the overall approach appears to take a single or, at best, a multi-species management approach, rather than an ecosystem-based approach.

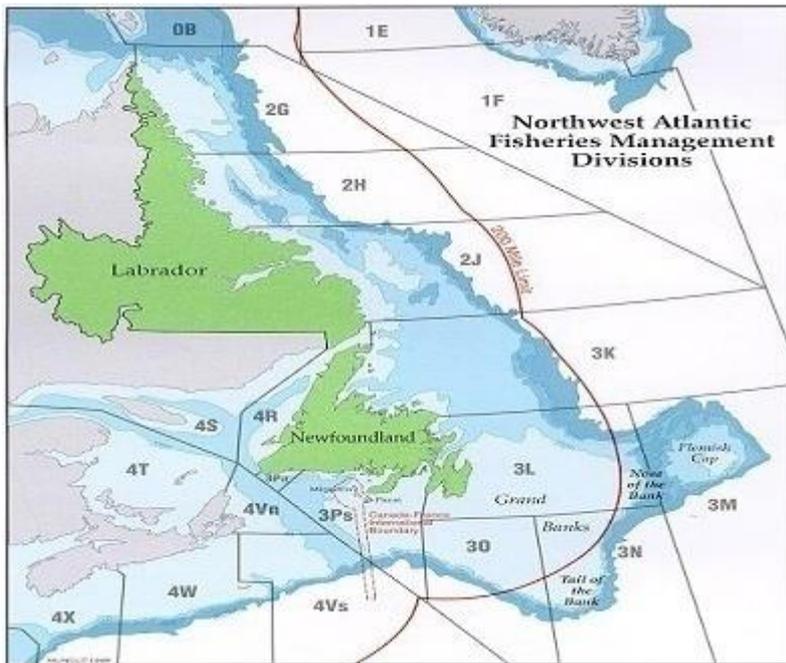


Figure 8: Canada's Atlantic fisheries divisions, the 3Ps cod fishery is south of Newfoundland (DFO, 2009b; <http://data.gc.ca/eng/open-government-licence-canada>)

Based on this superficial analysis, a fishery like this might be assessed under the MSC habitat management performance indicator as having 'measures', but not a partial strategy: there are a collection of tools used but each is aimed at species management. Such measures may afford some protection from serious or irreversible harm for some habitat in the fishery, but they primarily make an indirect contribution to the management of the habitat component. Therefore, they would meet the standard required under the Habitat Management performance indicator at the 60 level, but not the 80 level of performance. However, if the habitat policy does become demonstrably implemented in Canadian fisheries management plans, certification assessments may judge the subsequent management arrangements as 'partial strategies' (i.e. ≥ 80) or even elevate them to overt and explicit habitat management 'strategies' required by the MSC standard to score 100 for the Habitat Management performance indicator.

USA

At a system level:

The overarching framework for managing the US's fisheries are the statutes: *Magnuson-Stevens Fishery Conservation and Management Reauthorization Act, 2006*; the *Endangered Species Act, 1973*; and the *Marine Mammal Protection Act, 1972*. Further habitat-related instruments include the *Coral Reef Conservation Act, 2000* and the *Marine Protected Areas Executive Order, 2000*.

The Magnuson-Stevens Act provides for the conservation and management of US fisheries resources by requiring the development of fishery management plans and calls for government fisheries 'managers' (i.e. NOAA Fisheries) to work with regional Fishery Management Councils to develop plans for each fishery under their jurisdiction. One of the required provisions of fishery management plans specifies that essential fish habitat be identified and described for the fishery, adverse fishing impacts on essential fish habitat be

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minimized to the extent practicable, and other actions to conserve and enhance essential fish habitat be identified. The Act also mandates that NOAA Fisheries coordinate with and provide information to federal agencies to further the conservation and enhancement of essential fish habitat. The provisions of the Act have been interpreted by NOAA Fisheries to mean that essential fish habitat for all life stages of around 1,000 federally managed fish species is needed to be taken into account under management plans (NOAA, 2011a).

Critical habitat is a designation used under the *Endangered Species Act* and relates to the survival and recovery of some 64 species listed as threatened or endangered under the Act. Such critical habitats include areas occupied by listed species that are necessary for the conservation of the species and may require special management provisions or protection (NMFS, date unknown).

In February 2009, NOAA received US\$167 million from the *American Recovery and Reinvestment Act, 2009* to restore coastal habitat and help jump-start the nation's economy by supporting thousands of jobs. The agency is funding 50 high priority coastal restoration projects ranging from rebuilding oyster and shellfish habitat to protecting areas of coral reef (NOAA, 2011b).

In 2010, NMFS published a plan to improve the scientific assessment of habitats in order to meet a number of goals, particularly in relation to being able to identify essential and critical fish habitats and to incorporate habitat science into stock and fishery assessments in order to reduce habitat-related uncertainty (NMFS, 2010). Another important goal of the plan is to contribute to broader ecosystem-based fishery management, integrated ecosystem assessments and coastal and marine spatial planning (ibid).

The plan acknowledges that, to the time of writing, designation of essential fish habitat for federally managed fish stocks had been based on inadequate information and used a single-species approach rather than an ecosystem-based approach, resulting in so-called essential habitats that were generally too broadly defined to provide for meaningful management measures. More accurate assessments of the distribution and abundance of many fish stocks would be enhanced by improved information about their associated habitats, as would understanding about habitats' contribution to biodiversity and ecosystem sustainability (ibid).

Fishery-specific level:

Georges Bank groundfish and scallop fisheries

In 1994, fisheries managers closed three large areas of the Georges Banks off southern New England to any fishing gear capable of retaining groundfish (trawls, scallop dredges, gill nets, hook fishing) to protect groundfish spawning and juvenile production (Murawski *et al.* 2000). Understanding of the factors influencing complex fish assemblages influenced which areas to close. These factors included habitat type, ocean temperature and depth. Over the next five years evidence demonstrated that the closed areas provided significant protection for shallow-sedentary fish species (e.g. flounders and skates) and bi-valve molluscs (e.g. scallops) (ibid). An association between juvenile groundfish and gravel/cobble seabed habitat led to the designation of a "habitat area of particular concern", partly in response to a need to take more explicit account of habitat protection in fisheries management (ibid). Research surveys on biological communities in fishing impacted habitats and undisturbed nearby habitats before year-round closures were implemented revealed that undisturbed sites, perhaps unsurprisingly, had higher numbers of benthic organisms, biomass, species richness and diversity than the fishing impacted sites, and faunal communities were dominated by larger organisms. The closed areas were deemed to have contributed to reducing groundfish fishing mortality and improving spawning-stock biomass for species like cod and haddock. Sea scallop biomass increased 14-fold in closed areas between 1994 and 1998 (Figure 8) and the results were said to have been far more effective than other management tools used elsewhere. A significant effect of the closures for scallop and groundfish management, however, was the protection of habitat deemed

essential for finfish and scallop recruitment, along with “*serendipitous beneficial impacts on a wide range of other species*” (Murawski *et al.* 2000). Year-round closures of large areas were said to be easier to enforce than seasonal, smaller areas and compliance appeared to be “relatively good” with the introduction of vessel monitoring systems, high presence of coast guard and aerial patrols and increased sanctions (*ibid.*).

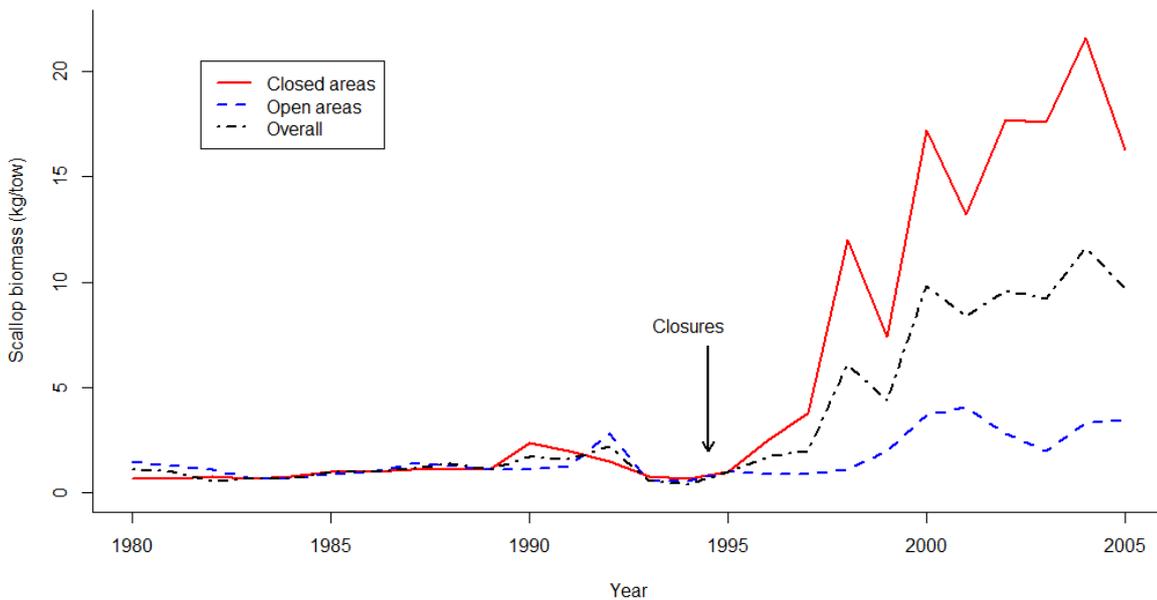


Figure 9: Sea scallop biomass increases after habitat is protected from bottom-impacting fishing gear. Source: NOAA, <http://www.nefsc.noaa.gov/sos/spsyn/iv/scallop/>

The relatively simple approach of closing areas to bottom impacting fishing gear is fraught with scientific complexity, particularly in ensuring that habitat protection measures will serve either fisheries and/or ecosystem management purposes. In this case, the evidence suggests that in a multi-species management context, the closed areas protected habitat vital to the productivity of the fishery and the knock-on effects were beneficial for a range of other species. In that sense, were a certification body examining this management approach in the context of the Habitat Management performance indicator, the measures may add up to a partial strategy, with perhaps some extra points awarded for the ongoing scientific efforts to understand the relationship between the habitat, its protection and the sustainability of target fish stocks.

West Coast Groundfish Essential Fish Habitat (EFH)

According to NMFS (2010), around 2003-04 a habitat assessment was conducted as part of an Environmental Impact Statement on EFH designation and minimization of adverse impacts to the habitats of 82 species of west coast groundfish, including 40 key stocks. The assessment included innovative habitat suitability and risk models, an internet-based habitat-use database, and the first step in the development of seafloor habitat maps for the entire west coast (Figure 9). The habitat assessment also compiled information on the status of habitats important to groundfish and the impact of fishing on those habitats. While lacking information on the contribution of habitats to the productivity of fish populations and the capacity of specific habitats to recover from various types of fishing impacts, the assessment provided the scientific justification for proposing and implementing several significant management measures to

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protect EFH from adverse impacts of fishing (Figure 10 and 11). These included a long-term managed reduction in fishing pressure and the designation by the Pacific Fishery Management Council of a network of no-trawl zones and fishery closures along the US west coast of around 1.5 million hectares of ocean (Figure 12). Scientists believe the closures will improve their understanding of the use of marine protected areas to help manage fisheries and result in increased protection of sensitive seafloor habitats and associated species (NMFS, 2010).

Parallel to the scientific efforts, The Nature Conservancy and Environmental Defense engaged with a small section of the Californian trawl industry and gained fisher support for an NGO buy-out of trawl permits in return for support of the habitat protection measures (Niesten & Gjertsen, 2010). In 2006, the NGOs planned to lease the permits back to those in the fishing community who commit to using more sustainable fishing gears and practices (ibid). As part of a strategy to reduce impacts on benthic habitats, the buy-out further contributed to reducing trawl effort outside the no-trawl zones.

NMFS scientists hold up the west coast groundfish fisheries as an example of how habitat assessment contributed to improved policy development and management in fisheries. However, given that they acknowledge the assessment's limitations for understanding the impacts of fishing on benthic habitat and that single species assessment and management considerations mainly inform designation and management of essential fish habitat in many fisheries management plans, it is difficult to envisage anything more than a 'partial strategy' rating being awarded to the west coast groundfish fishery. If the NMFS plan gets the funding it seeks and systematically re-assesses fisheries plans to improve habitat assessments and integrate new scientific findings into management considerations and decisions on the water, a rating of 'strategy' may be applicable.

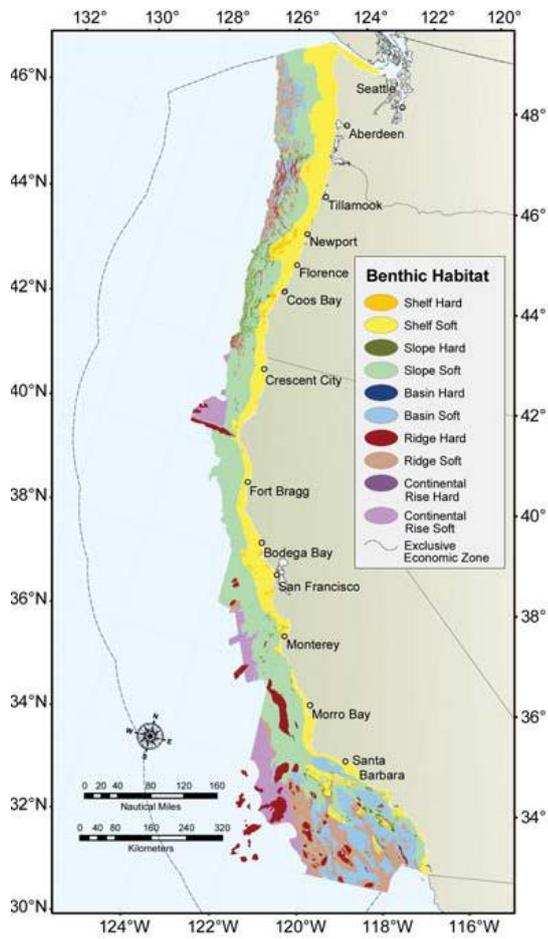


Figure 10: Pacific coast groundfish essential fish habitat map used in risk assessment. NMFS, 2010 citing Goldfinger *et al.* 2003 and Greene *et al.* 2003; http://www.st.nmfs.noaa.gov/st4/documents/habitatAssessmentImprovementPlan_052110.PDF

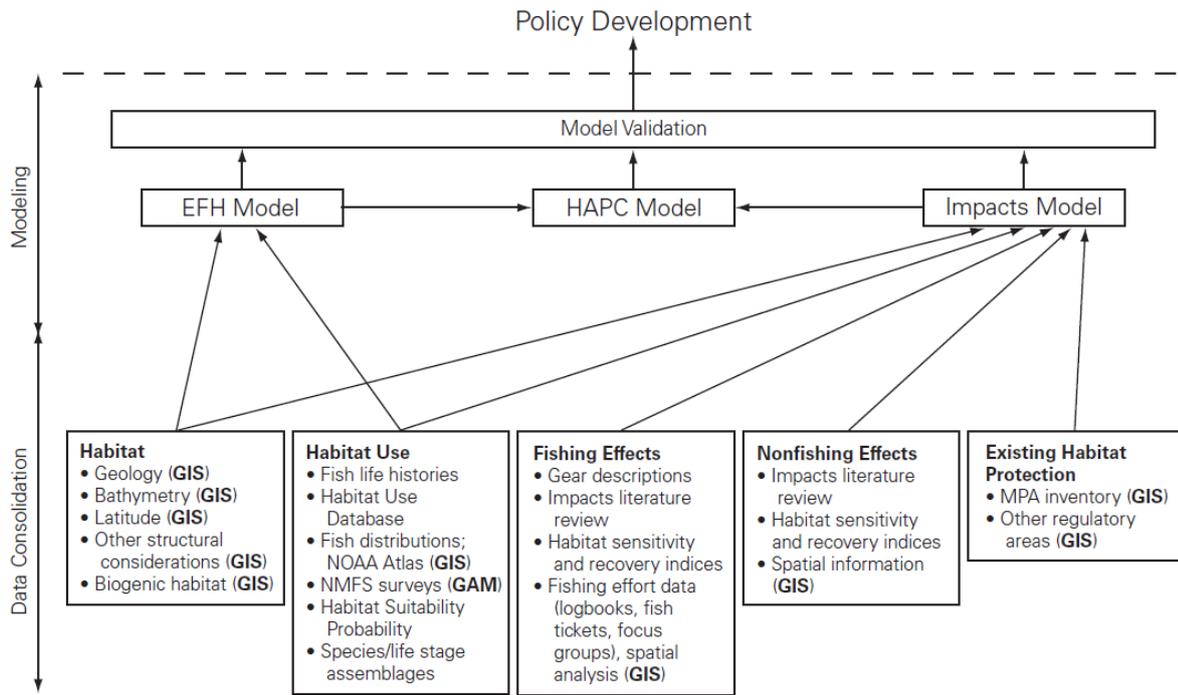


Figure 11: Decision-making framework guiding science for habitat assessment and policy development for groundfish essential fish habitat (NMFS, 2010; http://www.st.nmfs.noaa.gov/st4/documents/habitatAssessmentImprovementPlan_052110.PDF)

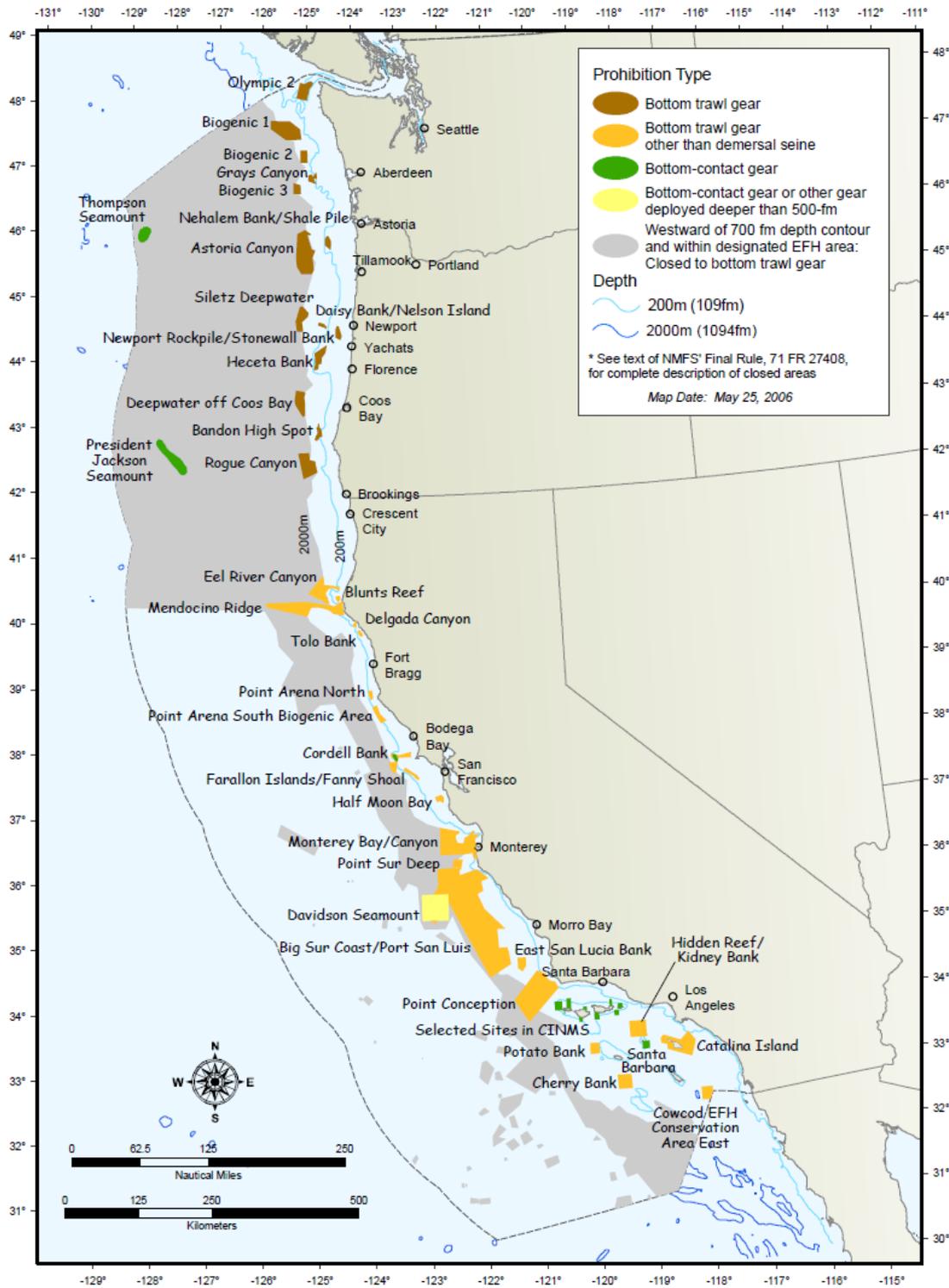


Figure 12: Essential fish habitat fishing gear area closures (PFMC, 2006)

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Conclusions and recommendations

The following conclusions were drawn from the original research and analysis commissioned by the MSC and the recommendations were written for the MSC and its Technical Advisory Board to help progress understanding and thinking about how to interpret the Habitats performance indicators. As such, the conclusions and recommendations should be taken in that context.

Defining Habitat, Habitat Structure and Habitat Role

At the time of writing, neither MSC's Certification Requirements nor MSC Guidance adequately defined "Habitat", "Habitat Structure" or "Habitat Role" which are terms used in the Habitat performance indicators. Section AA3 Vocabulary of the MSC Certification Requirements should define these terms.

The closest thing to a recognisable definition we discovered in the MSC scheme documents is buried in the Guidance document, page 100, paragraph GCC2.1.5, in relation to interpreting the MSC's risk based framework (RBF):

"...The basic unit is a habitat type, defined as either pelagic (encompassing the water-column), or benthic (the seafloor structure including its attached invertebrate fauna)...."

The MSC Guidance goes on to say:

"Identifying benthic habitat types has proven challenging due to the dispersed and variable nature of habitat data. Whatever data does exist varies in type, scale, quality and consistency, and perhaps most importantly, accessibility. In the RBF we use a standardized way of identifying benthic habitat units, by Substratum Geomorphology and Fauna (SGF). For example, one habitat type could be fine sediments—flat seabed—mixed epifauna. Each SGF combination with which the fishery interacts should be noted." (GCC2.1.6)

We said in our [previous paper](#), in the section on Definitions that "in defining habitat types within the Risk Based Framework, the MSC uses the Substratum, Geomorphology, Fauna (SGF) method which implies that the habitat includes the organisms living therein. However, while habitat simply refers to an area inhabited by a particular organism, a biotope refers to both the habitat and its associated species (Costello, 2009). Often a species and a habitat are indistinguishable (e.g. coral reefs and other biogenic structures) and are at the very least dependent." So, for the purposes of our report, we used the MSC-derived approach suggesting that habitats are the bio-physical region inhabited by targeted fish, which will very often include habitat-forming non-target species.

The dilemma for the MSC, as we saw it at the time, was that scientists from the fisheries and ecology disciplines do not use standardised meanings to describe the complex and diverse concepts, processes and properties of ecosystems, much less habitats. Even within ecology there appears to be a 'physics-biology duality problem' when describing ecosystem components like habitats (Gignoux *et al.* 2011). Indeed, Jax (2006), after a comprehensive analysis, proposed 'operational definitions' related to generic meanings to enable reasonable discussion within the scientific community. Habitat could therefore simply be defined as the *chemical and physical environment where an organism resides*. The subtlety lies in the fact that habitat refers only to an area and not the larger biological community or biotope. However, as with many scientific disciplines, the ontological debate continues.

In the interest of being practical, we recommend that the MSC, at a minimum acknowledge the definitional debate while setting out its own definition for habitat based upon the above guidance it already gives, with some minor tweaks. For example:

“For the purposes of a fishery assessment against the MSC standard, habitat is defined as the chemical and bio-physical environment where an organism resides. The basic units are either pelagic habitats (the water column) or benthic habitats (the seafloor structure including its attached flora and invertebrate fauna).”

Note that we included *flora* in the above recommended definition: seaweed, seagrasses, kelp and other attached flora can have important habitat-forming or functional properties that may be impacted by fishing as much or more than attached invertebrate fauna. Adding flora to the definition may then have implications for the above SGF means of identifying benthic habitat units. So, perhaps another term may be added to the identification of benthic habitat units – SGF(F) – so that when appropriate and relevant important floral features that may be impacted by bottom-contacting fishing gear may also be recognised and assessed. For example, *hard substrate – flat rocky terrace – mixed epifauna – kelp forest (or: fine sediments – sub-tidal sand plains – mangrove mangal)*.

In the context of ‘habitat structure’, this is the amount, composition and three-dimensional arrangement of biotic and abiotic physical matter within a defined location and time; it refers to the complexity and heterogeneity of physical matter across horizontal and vertical physical space (McCoy & Bell, 1990). In more simple terms, ‘habitat structure’ refers to the physical arrangement of matter that supports plants and animals (Warfe & Barmuta, 2004). Habitat structure is but one aspect of habitat that has been demonstrated to provide refuge and increased surface area for food production. But habitat structure is also almost certainly the aspect of habitat most threatened by the benthic impacts of fishing.

‘Habitat role’ might be defined as the range of services provided to an organism or ecosystem, including, but not limited to, mediating trophic interactions between predator and prey and between predators, providing refugia, and influencing behaviour of organisms (Warfe & Barmuta, 2004), thus having multiple influences upon ecosystems. For example, seagrasses or mangroves may provide predator refuge, whilst adjacent soft bottom environments may provide foraging opportunities. It is important to note that these services may be life stage and size dependent, and can change according to the density of biotic and abiotic physical matter within the habitat structure itself. For example, seahorses were observed changing from a searching mode of foraging to an ambush strategy as seagrass habitat became more dense (Warfe & Barmuta, 2004).

We offered the above concepts and considerations as a starting point for the MSC to begin discussions about how to define ‘habitat structure’ and ‘habitat role’ within the MSC Certification Requirements.

Destructive practices

The term “destructive practices” refers to the use of fishing gears in ways or in places such that one or more key components of an ecosystem are obliterated, devastated or ceases to be able to provide essential ecosystem functions. From an ecosystem and precautionary principle perspective, destructive fishing refers to the use of gears and/or practices that present a high risk of local or global damage to a population of target, associated or dependent species or their habitat, to the point of eliminating their capacity to continue producing the expected goods and services for present and future generations, particularly if recovery is not possible within an acceptable time frame. Few, if any, fisheries are consistently “destructive”. Only a very small number of fishing gears or fishing methods are recognized as inherently “destructive” wherever and however they are used, the primary examples being explosives and synthetic toxins (poisons) which are already excluded from the scope of an assessment against the MSC standard. In the absence of any formal international agreement or consensus regarding the term, the classification of a gear or practice as destructive comes down to a policy choice related to pre-set objectives that may be consistent with national law.

Recovery and reversibility

There has been substantial interest in the concepts of recovery and reversibility of impacts in all ecosystems, marine and terrestrial. In general there is incomplete and often little understanding of the likelihood and nature of recovery of marine systems from substantial perturbations. However, a number of issues and tentative conclusions emerge from most studies of recovery of marine ecosystems or reversibility of specific perturbations:

1. Ecosystems vary greatly in their capacity to recover from impacts, for many different reasons.
2. Different types of impacts differ greatly in both likelihood that they cause substantial changes to ecosystems and the likelihood that recovery from the changes will be rapid and secure.
3. Ecosystems will not follow the same path during recovery that was taken during the period when the perturbation was occurring. Indeed, there are many cases where ecosystems undergo a regime shift and a demonstrable hysteresis (A lagging of an effect behind its cause) has been documented for many ecosystems recovering from anthropogenic disturbances. A hysteresis is the dependence of a system not just on its current environment but on its past.
4. Ecosystems are naturally variable, so even a successful recovery program will not return an ecosystem to exactly the state it was in prior to the perturbation. This is linked to the idea of shifting baselines. Specifically, it is difficult to define recovery since the natural state is often ill described or unknown.
5. What point constitutes recovery – presence or maturity?

Ecosystem approaches (EA) to fisheries and integrated management (IM)

Biodiversity considerations are a major component of bringing both the ecosystem approach and integrated management into fisheries. They are part of both major challenges in IM and EA, dealing with:

Multiple effects – Accounting for multiple drivers in setting objectives, choosing indicators, setting reference levels, and diagnosing causes of changes. The latter is of particular concern because of the resultant difficulty in determining what activity (manageable or not) is causing a detrimental trend in a target habitat characteristic, or if improvements in a habitat characteristic is due to management actions or a natural process.

Complexity of management options – How to account for pressures from multiple human activities and how to allocate necessary mitigation actions fairly and effectively among multiple user communities. This is a challenge even when harmonizing management options across sectors for a single ecosystem feature such as a stock fished by several communities. It becomes much more complex when management options must be harmonized across many groups with different goals, and considering many different biodiversity features.

Innovation

Innovation in fishing gear and operational characteristics have long been driven by a desire by fishers, engineers and scientists to improve fishing efficiency. Over the last few decades science has invested much effort in improving fishing gear to reduce environmental impact. In Europe and perhaps around the world, many of these efforts were not taken up by the fishing industry. There was a perceived lack of incentive and fisheries management did not seem to be able to address issues of technological innovation while grappling with fleet overcapacity and ‘technology creep’ issues contributing to overfishing and stock depletion. In the last decade, however, rising fuel prices and ecolabels such as MSC have had a clear influence on the finances of fisheries. Fuel prices have increased the cost of fishing, especially those methods with high fuel consumption, to a level where they are barely viable without government financed aid, fuel subsidies or fuel tax exemptions which act to reduce the direct and indirect costs of fishing.

The increasing success of ecolabels have made fishers aware that if they do not improve their sustainability credentials, demand for their products in global markets may fall, along with the value of their catch. These two factors are influencing industry-led innovation which seeks to improve both the sustainability and profitability of fisheries by reducing impact and lowering the actual cost of going fishing. As such, many more initiatives are leading to improved and even new types of fishing gear with reduced discards, reduced seafloor impact and reduced fuel consumption.

Initiatives such as WWF’s International Smart Gear Competition encourage innovation and design. We have highlighted two WWF-award winning designs in this report that have demonstrably led to reduced benthic habitat impact (the CP2 Batwing from Australia and the Hovercran from Belgium). Initiatives such as WWF’s competition are to be encouraged – perhaps there is room for another NGO-sponsored competition which focuses specifically upon reducing impact upon benthic habitat rather than the principally bycatch reduction focus of the WWF competition?

For the MSC there is the option of creating written guidance that helps certification bodies acknowledge the design and creation of technological innovations which demonstrably reduce impacts on benthic habitats and are taken up and used in fisheries. Some of the new or adapted devices mentioned in our ‘examples of improved practice’ should lead not only to significant reductions in benthic impact on habitat structures, but also improved environmental outcomes for benthic organisms and improved fishing (e.g. fuel) efficiency for fishers. This surely is a win-win-win situation. We recommend that examples such as these, that achieve

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such impressive outcomes, should score highly as ‘best practices’ (i.e. over the 80 scoring guidepost) under MSC’s Habitat Outcome and Management performance indicators, potentially creating incentives for further innovation in gear technology and design that lessen benthic habitat impacts.

‘Big science’ versus data deficiency

We have noted throughout our report that solutions in developed countries to questions about ‘best practice’ in monitoring, measuring, managing and mitigating the benthic impacts of fishing often rely upon expensive and complex research (e.g. sophisticated habitat mapping and ground-truthing physical surveys, or gear technology innovation) and labour-intensive, content-rich management processes (e.g. ecological risk assessment and risk management, or implementation of complex networks of fishery closures or protected areas). These approaches rely upon ‘big science’ and well-funded approaches to fisheries management and enforcement. We have also acknowledged that in many developing economies and quite a few developed ones, that habitat information and the knowledge about actual benthic impacts of fishing is ‘data deficient’. In these cases we have suggested how co-management, or precautionary and risk-based approaches may offer examples of best practices for habitats. We also encourage the continued efforts of the MSC to develop the Risk Based Framework under the MSC Certification Requirements to enable certification bodies to effectively assess data deficient situations against the Habitat Outcome performance indicator.

None of what we have presented in this report should be transformed into prescriptive inputs or specific requirements – to do that may raise the bar of the MSC standard, which is beyond the scope of this research project. Rather, we have attempted to present a multitude of practices that might work *together* to meet the current level of performance required by the three Habitat performance indicators. We have tried to capture both the cutting edge of innovation, as well as more down to earth examples of best practice. We are especially cognisant of the need for the MSC standard to be interpreted based upon the language of the scoring guideposts, and not by a list of expected monitoring methods, prescriptive analytical tools, defined management strategies or preferred mitigation actions. As we pointed out in the introduction, each one of these and their application will be contextual, and should be appropriate to the scale and intensity of the fishery under assessment.

Conclusion

This report (including [previous paper](#)) demonstrated how best practice in relation to understanding and managing the impacts of bottom-contacting fishing gear on habitats is contextual. Technology changes rapidly and if improved technical practices do make it into the peer-reviewed literature, often the time lag means technology has changed again. For these reasons, we did not delve too deeply into ‘quantifying’ best practices from all over the world. Instead, we presented some of the latest thinking about monitoring, measuring, managing and mitigating from three perspectives: the physical habitat, the fishing gear and the management regime.

So, rather than a site-specific list of gear, habitat, and management combinations that would certainly not be exhaustive and may have limited utility or applicability in different contexts, we took a mechanistic perspective. Identifying the mechanisms by which specific gear components impact habitat structure (e.g. homogenization) and ecosystem services (e.g. production of benthos) based on habitat characteristics (e.g. sediment grain characteristics) will allow the MSC’s assessment procedures the flexibility to adequately characterize impacts and identify best practices in fished, data deficient or newly fished areas. For example, wherever possible, fishing gear was broken into specific component impacts (e.g. ground rope, tickler chain, and sole plate) to allow for a more flexible assessment of best practices even as gear inevitably changes or as fisheries enter different habitats. Similarly, from a monitoring perspective, our work identified data sources and methods by which under-sampled (data deficient) areas can be understood and

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assessed regardless of whether in developed or developing countries (e.g. co-management, ecosystem models derived from analogous data rich locations). Optimally, the lessons of specific gear/habitat interactions should be mechanistic and through this understanding, best practices can be tailored to the situation, including unforeseen future scenarios.

From the habitat science perspective we showed that habitats that experience little natural disturbance will be particularly susceptible and vulnerable to significant impacts from bottom-contacting fishing gear and, ideally, should be managed with extreme precaution (e.g. deep sea habitats and large, long-lived, sensitive biogenic structures like deep sea and tropical corals). We also suggested that habitats are a mosaic of multiple habitat types and should be treated as an integrated unit, although how to do that effectively is a more difficult issue to overcome.

From a technological perspective, we provided a vast amount of information that might inform the MSC about existing fishing gears and their impacts, as well as the latest technology that promises to reduce impacts on benthic habitats in the future.

From a management perspective, we identified a significant amount of movement towards active consideration of habitats, much of which is driven by objectives other than strictly fisheries management, but in which fisheries management plays a part. Increasingly, however, developed world science and management is getting its collective head around the needs and challenges of integrating habitat and fisheries science and management within ecosystem-based frameworks. In developing countries however, the challenges are more complex not least of which are the relative levels of data and access to expensive research facilities or engineering technology. Many initiatives, however, may come at the issues from community perspectives or broader conservation objectives may result in good outcomes for fisheries and their associated habitats.

In the final analysis, though, data deficiencies may yet plague both developed and developing countries in their efforts to understand and manage the impacts of fishing on benthic habitats. We acknowledged these challenges, and the fact that the MSC itself is working on developing its Risk-Based Framework methodology to include not only Scale Intensity Consequence Analysis, but also include a Productivity Susceptibility Analysis dimension. Against that backdrop, we intended the original report to help bridge some of the conceptual gaps in the bigger picture for the MSC and provide food for further thought in the development of the MSC Certification Requirements and its related Guidance material.

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