

The background of the cover is an underwater scene with sunlight filtering through the water. In the bottom right corner, a silver fish is shown on a white plate, appearing to be part of the underwater environment.

Best Fish Guide 2009-2010

How it works
(Assessment Methodology)



Forest & Bird
GIVING NATURE A VOICE

Best Fish Guide 2009-2010

How it works (Assessment Methodology)

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1. Introduction

New Zealand has one of the largest marine areas in the world, covering more than 1% of the Earth's surface and 23 times our land area. The marine areas of New Zealand's Exclusive Economic Zone (EEZ) and continental shelf are incredibly diverse. They range from sub-tropical oceans in the north, to temperate waters around the mainland and cool sub-Antarctic waters in the south.

Many of our marine species are found nowhere else in the world. Scientists estimate that more than 80% of New Zealand's biodiversity is found in our oceans (NZ Biodiversity 2000), and much more is yet to be discovered. About 15,000 marine species are known, while it is estimated that another 50,000 species are yet to be discovered – new species are being found all the time.

Our marine area is also a vital part of our economy, supporting out \$1.5 billion fishing industry and our \$20 billion tourism industry.

It is also central to our national identity: most New Zealanders live near the ocean and have a close relationship with the marine environment. We collect kaimoana or seafood, swim, surf, dive, snorkel and sail, and appreciate the variety of marine life.

The the Royal Forest & Bird Protection Society of New Zealand Inc. (Forest & Bird) has a vision for New Zealand's fisheries. By 2030:

- We will have a healthy and diverse marine environment supporting an abundance of marine life, where profitable fisheries operate alongside other activities.
- Adverse impacts of fishing on the marine environment have been repaired or mitigated, and “nursery areas” important for replenishment of populations are protected.
- New Zealand meets or exceeds world's best practice in fisheries management and environmental practice, so it can market truly sustainable products worldwide.

This report presents the background and methodology behind the Forest & Bird's Best Fish Guide - a guide to inform seafood consumers and encourage environmentally sound choices of seafood. .

The *Best Fish Guide* methodology was first developed in 2002, following extensive international research of similar fisheries certification and assessment methodologies (Weeber and Wallace 2008). The first *Best Fish Guide* was completed and published in November 2004.

This report supports the 2009-2010 *Best Fish Guide*, representing the fourth edition of the guide. While the methodology has not changed significantly since the original version, it is updated with each review of the guide to reflect changes in available information (see Weeber 2004, 2005 and 2007 for earlier editions of this report).

2. Why an ecological assessment?

The main objective of any ecological certification or ecolabelling scheme is to create a market-based incentive for better management of fisheries. It does this by stimulating consumer demand for fish and other seafood products sourced from ecologically sustainable fisheries and well-managed stocks (Wessells *et al* 2001, Deere 1999, Phillips *et al* 2003).

The UK based Marine Stewardship council (MSC) is one of the largest international seafood assessment bodies, awarding fisheries with certifications for meeting fisheries management standards and practices.

In 2002, Forest & Bird objected to the MSC's controversial environmental certification of the New Zealand hoki fishery. We did so because, amongst other issues, the hoki fishery was causing the deaths of hundreds of NZ fur seals and globally threatened seabirds, including albatrosses, each year. Due to the use of mid water and bottom trawl gear, it also was having significant impacts on seabed habitats and non-target species.

As a result of the New Zealand hoki fishery undeservedly being awarded ecological certification, combined with general frustrations about New Zealand's fisheries management, our non-profit organisation began a review of marine certification systems and consumer assessment guides.

Around the world there are a number of approaches to evaluating the ecological sustainability of seafood. For example, the Marine Conservation Society UK's *Good Fish Guide* (Clark 2002), Monterey Bay Aquarium's *Seafood Watch* program, Blue Ocean Institute's *Guide to Ocean Friendly Seafood*, Greenpeace's *Red Fish List* and the Australian Marine Conservation Society's *Sustainable Seafood Guide*.

After realising that there was a lack of information for New Zealand consumers on the ecological sustainability of commercially caught marine fish, Forest & Bird developed the *Best Fish Guide*.

The *Best Fish Guide* ecological assessment is used to categorise and rank commercial marine fisheries on the basis of the ecological sustainability of fisheries plus the impact that fishing has on target species, non-target species, and the wider marine environment (see also Weeber and Wallace 2008).

The assessment is not applied to fish or seafood imported from other countries such as tinned and frozen fish, or seafood from aquaculture. Nor does it assess regional variations in fisheries. It assessed average fisheries based on methods, impacts and management.

One of the aims of the *Best Fish Guide* is to provide consumers with information on the genuine state of our fisheries and guide seafood buying choices that supports moves towards genuine fisheries sustainability.

Since its first development, the *Best Fish Guide* methodology has remained relatively unchanged – it has simply been updated to reflect the latest government and published information about the target seafood species and associated bycatch species.

In 2006, the hoki fishery reapplied for the MSC certification. Forest & Bird and WWF-NZ objected on the grounds of inappropriate scoring, the discovery of illegal dumping of small fish, depleted state of the western stocks and ongoing deaths of marine mammals, seabirds and non target species. Despite these objections the hoki fishery was recertified as a "sustainable" fishery in October 2007 and will remain so for the duration of the 5 year certification period.

An ecological assessment method to assess fisheries in the State of Victoria, Australia was developed by Bathgate (1999) for the Victorian National Parks Association. As Bathgate notes:

"Certification of fisheries is extremely complex (given our limited knowledge of fishstocks) and can be difficult to define, particularly in multi-species fisheries that utilise a range of harvesting techniques...Despite these difficulties it is possible to conduct a 'snap-shot' assessment of various components of a fishery, of a fishstock in terms of ecological sustainability. ...Ecologically sustainable practices and management should enable fisheries to continue without deleterious effects on fishstocks, habitat or marine communities."

Forest & Bird hopes that the *Best Fish Guide* will help inform consumers and encourage them to make the best choice for our oceans – and avoid buying into what we are simply told is sustainable.

3. Key principles underpinning the Best Fish Guide

3.1 Ecosystem approach

Ecosystem-based management is more comprehensive and holistic than a single-species approach (Mangel *et al* 2000) and includes considerations of trophic interactions, habitat impacts of fishing gear, precautionary management, and marine reserves (Pauly *et al* 2002, Ecosystem Principles Advisory Panel 1999, Mace 2001, Ward *et al* 2001).

The approach used by the *Best Fish Guide* is consistent with an ecosystem-based management regime (Ecosystem Principles Advisory Panel 1999, Dayton *et al* 2002). Such an approach requires:

- “1) Knowledge of the total fishing mortality on targeted and incidentally caught species, including mortality resulting from regular discards and bycatch;
- 2) Investigations of links between species (eg predator and prey, competitors) and the habitat within which they reside; and
- 3) Recognition of the trade-offs to biodiversity and population structure within ecosystems that result from high levels of extraction.” (Dayton *et al* 2002).

As Dayton *et al* (2002) noted “currently fishing practice effectively ignores these essential requirements”. Forest & Bird considers that these requirements are an essential part of an ecologically sustainable fisheries management regime (ECO and Forest & Bird 2001).

3.2 Precautionary management

In assessing fisheries in New Zealand Forest & Bird has applied a precautionary approach. The precautionary approach has been very widely recognised in fisheries management internationally (UN Food and Agriculture Organisation (FAO) 1995a, Restrepo *et al* 1999, Gabriel and Mace 1999, FAO 1995b and UN Fish Stocks Agreement 1996).

Restrepo *et al* (1999) recommended that as part of the precautionary approach there should be a move away from using maximum sustainable yield (MSY) as a target to be achieved, but rather a limit to be avoided. Roughgarden and Smith (1996) have argued for maintaining stocks at higher biomass levels as a means of “buying natural insurance”. They recommended establishing a target stock at three-quarters of the average unharvested abundance. Lauck *et al* (1998) have also argued for protecting a substantial proportion (up to 50%) of the spawning stock from fishing as an insurance measure against errors when setting catch limits.

International agreements and measures have further articulated the precautionary approach. Section 5 of the Fisheries Act requires decision makers to act in a manner consistent with “New Zealand’s international obligations relating to fishing”. Amongst these obligations is the United Nations Food and Agriculture Organisation (FAO) Code of Conduct on Responsible Fisheries (1995), which states that:

“6.5 States and subregional and regional fisheries management organizations should apply a precautionary approach widely to conservation, management and exploitation of living aquatic resources in order to protect them and preserve the aquatic environment, taking account of the best scientific evidence available. The absence of adequate scientific information should not be used as a reason for postponing or failing to take measures to conserve target species, associated or dependent species and non-target species and their environment.”

Article 7.5 of the Code of Conduct further set out what constitutes precautionary management in fisheries.¹

The United Nations Implementing Agreement on High Seas Fisheries and Straddling Stocks² includes a requirement on “*coastal States and States fishing on the high seas [to] apply the precautionary approach in accordance with article 6.*” Article 6 includes requirements for:

- “1. *States shall apply the precautionary approach widely to conservation, management and exploitation of straddling fishstocks and highly migratory fishstocks in order to protect the living marine resources and preserve the marine environment.*
2. *States shall be more cautious when information is uncertain, unreliable or inadequate. The absence of adequate scientific information shall not be used as a reason for postponing or failing to take conservation and management measures.*”

This approach is consistent with the recommendation that the burden of proof should be reversed in fisheries management (Dayton 1998). Dayton recommended that those hoping to exploit marine ecosystems “must demonstrate no ecologically significant long-term changes”. The reversal of the burden of proof was also recommended by Restrepo *et al* (1999) as a mechanism for applying the precautionary approach.

4. How does the ecological assessment work?

The *Best Fish Guide* assessment looks at 6 different issues (criteria), adds weighting for each criterion, assesses the extent to which a fishery meets all of the criteria and gives each fishery an overall ecological ranking for sustainability. The following section further explains the assessment process applied to each species or species group.

4.1 Assessment criteria

After reviewing Bathgate’s (1999) seafood assessment criteria for the Victorian National Parks Association and similar approaches overseas (eg Deere 1999, Environmental Defense 2002, Tuominen and Esmark 2003, Seafood Choices Alliance 2004, Marine Conservation Society 2002), Forest & Bird developed six criteria for the *Best Fish Guide* as the basis of assessing the status of New Zealand’s commercial marine fisheries :

¹ 7.5 Precautionary approach

- 7.5.1 States should apply the precautionary approach widely to conservation, management and exploitation of living aquatic resources in order to protect them and preserve the aquatic environment. The absence of adequate scientific information should not be used as a reason for postponing or failing to take conservation and management measures.
- 7.5.2 In implementing the precautionary approach, States should take into account, inter alia, uncertainties relating to the size and productivity of the stocks, reference points, stock condition in relation to such reference points, levels and distribution of fishing mortality and the impact of fishing activities, including discards, on non-target and associated or dependent species, as well as environmental and socio-economic conditions.
- 7.5.3 States and subregional or regional fisheries management organizations and arrangements should, on the basis of the best scientific evidence available, inter alia, determine:
stock specific target reference points, and, at the same time, the action to be taken if they are exceeded; and
stock-specific limit reference points, and, at the same time, the action to be taken if they are exceeded; when a limit reference point is approached, measures should be taken to ensure that it will not be exceeded.
- 7.5.4 In the case of new or exploratory fisheries, States should adopt as soon as possible cautious conservation and management measures, including, inter alia, catch limits and effort limits. Such measures should remain in force until there are sufficient data to allow assessment of the impact of the fisheries on the long-term sustainability of the stocks, whereupon conservation and management measures based on that assessment should be implemented. The latter measures should, if appropriate, allow for the gradual development of the fisheries.
- 7.5.5 If a natural phenomenon has a significant adverse impact on the status of living aquatic resources, States should adopt conservation and management measures on an emergency basis to ensure that fishing activity does not exacerbate such adverse impact. States should also adopt such measures on an emergency basis where fishing activity presents a serious threat to the sustainability of such resources. Measures taken on an emergency basis should be temporary and should be based on the best scientific evidence available.

² The United Nations Agreement for the Implementation of the Provisions of the United Nations Convention on the Law of the Sea of 10 December 1982 relating to the Conservation and Management of Straddling Fish Stocks and Highly Migratory Fish Stocks (in force as from 11 December 2001).

- Status and sustainability of fish species catches;
- Impacts of fishing method (including level of bycatch and impact on habitat);
- Biology and risk of over-fishing;
- Effectiveness of management and research (including input and output controls, management plans, and stock assessment information);
- Bycatch of protected species or threatened species (such as seabirds, marine mammals and other species covered by schedule 5A of the Wildlife Act and threatened species ranked by IUCN or Department of Conservation);
- Effectiveness of management unit (including whether more than one species or stock are managed together).

The last two criteria are additions to Bathgate's criteria. These were added by Forest & Bird to better reflect the impacts of fishing on protected species such as marine mammals, seabirds, turtles and other marine life protected under New Zealand legislation³. It also assesses impacts on globally threatened species, and the risks associated with multi-species or multi-stock management that can occur under both quota and non-quota management systems in New Zealand.

The assessment of fisheries performance is limited by the absence of adequate fisheries information – a common problem worldwide. In New Zealand, of the 629 stocks managed by the Ministry of Fisheries, they estimate that only just over 100 stocks have adequate information to inform management decisions.

The Best Fish Guide assessment criteria were selected because enough information is available to assess each fishery against each one. They also provide a sound 'whole of ecosystem' basis on which to rank the overall ecological sustainability of each fishstock.

Other 'ecosystem approach' criteria could have been added, such as the presence of marine reserves in New Zealand. However, they were not used because marine reserve coverage is currently very small (around 0.3% of New Zealand waters or just 0.19% of mainland New Zealand's coastal waters). They have also been established as biodiversity protection tools, rather than fisheries management tools and as such are of limited significance to the fish species assessed by the *Best Fish Guide*.

4.2 Weighting of criteria

Each criterion was not considered equal in its contribution to the overall ecological sustainability of a fishery. Overall, status and sustainable yield were considered to be a better indicator of ecological sustainability, followed by fishing method, biology, management unit, and overall management and research (see Table 1). Protected species or globally threatened species bycatch was given a similar rating to status and sustainable yield because it gives a strong indicator of ecosystem health and the impact of a fishery on key species.

³ Seabirds, turtles, sea snakes and marine mammals are protected under the Wildlife Act 1953 and the Marine Mammals Protection Act 1978. Also protected under the Wildlife Act (Schedule 7A) are spotted black grouper (*Epinephelus daemeli*), black coral (all species in the Order Antipatharia), and red coral (all species).

Table 1. Weighting of criteria

Weighting constant	Criteria
3	Status and sustainable yield
2	Fishing methods
2	Biology and risk of over-fishing
1	Management and research
3	Protected species or globally threatened species bycatch
2	Management unit

4.3 Scoring

Each criterion has been scored on the basis of the extent to which the fishery meets it. The scoring for each criterion used a rating from 1 to 5 with:

- 5= Excellent (A)
- 4= Good, but with some inadequate features (B)
- 3= Weak, but with several mitigating features (C)
- 2= Inadequate, with at least one mitigating feature (D)
- 1= Wholly inadequate (E)

In line with the precautionary principle, where information is uncertain or unknown about the state of a stock or biological information, the fishery has been down-weighted in each assessment category. For each assessment criterion a category has been included where there is either inadequate information or none. In applying a precautionary approach, fisheries have usually been rated as a D or E for that criterion.

Overall scores

Each fishery / seafood species is assessed on the extent to which it meets each criterion using the weighting:

$$\text{Fishery rank for criterion} \times \text{Criterion weighting} = \text{Criterion Score}$$

The overall sustainability of a fishery is determined by adding the totals for all six criteria together to give an overall sustainability score.

$$\text{Scoring for: criteria 1} + \text{criteria 2} + \text{criteria 3} + \text{criteria 4} + \text{criteria 5} + \text{criteria 6} = \text{Overall sustainability score}$$

The fisheries are then ranked as:

- Green (A to C) – good to eat;
- Amber (D) – seafood of concern and
- Red (E) – seafood to avoid.

4.4 Limitations

It must be recognised that this assessment system, whilst based on the best information available, is in part subjective and qualitative rather than wholly quantitative. Further, the health and status of each fishstock will vary over time. Forest & Bird intends to regularly review fisheries to record long-term trends.

5. Assessment criteria – what do they mean?

The following section further explains the criteria used to assess the status of each fishery.

5.1 Status and sustainable yield

The status and sustainable yield of a fishery is a fundamental indicator of ecological sustainability or health of a fishery. Fishstocks are assessed annually by the Ministry of Fisheries stock assessment working groups, but few fisheries have detailed quantitative stock assessments (less than 20% of quota stocks, excluding the Kermadecs QMA 10).

Fisheries have been rated in accordance with the current information available and compared to the requirements of the principles of the Fisheries Act 1996⁴.

The assessment of the sustainability of New Zealand's fisheries is currently in a state of transition as the Ministry of Fisheries has recently adopted a new approach to managing stocks under the Harvest Strategy Standard – published in October 2008 (Ministry of Fisheries 2008a and b). On publication of this *Best Fish Guide* report, very few stocks had been assessed by this standard.

The aim in fisheries management is to achieve catches which mirror the long-term sustainable yield from the stock fished. In New Zealand a number of fisheries have failed to achieve this. For example, orange roughy, snapper, hoki, paua and rock lobster.

As is the case in many countries, New Zealand focuses stock assessments and fisheries management on single-species, rather than apply an ecosystem-based management approach, which is supported by Forest & Bird (ECO and Forest & Bird 2001, Link 2002).

An ecologically sustainable fishery can have a relatively constant stock size and stable catches over time. Or it can be one that tracks the natural population fluctuations over time and matches this to not exceed the productivity of the stock. In this situation neither the stock size nor the catch would be stable over time, but they would be harvested sustainably if the variable catch was always a low fraction of the current stock size. It also means that the biomass of new fish entering the fished population (recruited) as young fish is balanced by the biomass of fish dying from natural causes and caught by fishing.

Where fishing catches stay high, effort increases and fish are killed (including natural mortality) at a greater rate than they can reproduce, the population will continue to decline until it is uneconomic to continue fishing or until the population collapses.

⁴ **Purpose And Principles** of the Fisheries Act 1996 includes:

8. Purpose— (1) The purpose of this Act is to provide for the utilisation of fisheries resources while ensuring sustainability.

(2) In this Act—“**Ensuring sustainability**” means—

(a) Maintaining the potential of fisheries resources to meet the reasonably foreseeable needs of future generations; and

(b) Avoiding, remedying, or mitigating any adverse effects of fishing on the aquatic environment: “**Utilisation**” means conserving, using, enhancing, and developing fisheries resources to enable people to provide for their social, economic, and cultural wellbeing.

9. Environmental principles— All persons exercising or performing functions, duties, or powers under this Act, in relation to the utilisation of fisheries resources or ensuring sustainability, shall take into account the following environmental principles:

(a) Associated or dependent species should be maintained above a level that ensures their long-term viability:

(b) Biological diversity of the aquatic environment should be maintained:

(c) Habitat of particular significance for fisheries management should be protected.

10. Information principles— All persons exercising or performing functions, duties, or powers under this Act, in relation to the utilisation of fisheries resources or ensuring sustainability, shall take into account the following information principles:

(a) Decisions should be based on the best available information:

(b) Decision makers should consider any uncertainty in the information available in any case:

(c) Decision makers should be cautious when information is uncertain, unreliable, or inadequate:

(d) The absence of, or any uncertainty in, any information should not be used as a reason for postponing or failing to take any measure to achieve the purpose of this Act.

The amount of fishing pressure a population or stock can sustain is usually compared to the maximum sustainable yield (MSY) or some equivalent estimate of yield. Section 13 of the Fisheries Act requires the Minister of Fisheries to maintain a “stock at or above the level that can produce the maximum sustainable yield”.

Maximum sustainable yield in relation to any stock means the greatest yield that can be achieved over an indefinite period while maintaining the stock’s productive capacity, having regard to the population dynamics of the stock and any environmental factors that influence the stock. However, MSY is not without risk because it relies on perfect knowledge of catch, biological information and stock assessment information. It also assumes that there are no changes in environmental factors effecting recruitment or other parameters, and that management is perfect - with immediate responses to changes in sustainability information (Science Group, Ministry of Fisheries 2009).

As Restrepo *et al* (1999) and others recommend, there is a need to move away from MSY as a target and instead use it as a reference point limit to be avoided. Roughgarden and Smith (1996) have argued for higher target stock sizes at three-quarters of the average unfished abundance to avoid the collapse of fisheries.

Given the uncertainty with estimating yields and the known complexity, environmental variability, ecosystem effects, effects of serious disease events and lack of information about the marine environment, it is prudent to be cautious. Species should be harvested at a catch limit below the MSY level or equivalent level, and stocks maintained at or above the biomass that will support the maximum sustainable yield (B_{MSY}). For example, maximum economic yield (MEY) is usually a level of catch below the MSY level, because a lower cost of catching fish is maintained at a higher stock size.

MSY can be measured in a number of ways. In New Zealand, fisheries stock assessments usually refer to maximum constant yield (MCY) or current annual yield (CAY) as proxies for MSY (see Annala *et al* 2003 and Sullivan *et al* 2005). These are usually referred to as biological reference points and are defined below:

Definitions:

- MCY** - Maximum constant yield is the maximum constant catch that is sustainable with an “acceptable level of risk” at probable levels of future biomass for a fishstock.
- CAY** - Current annual yield is the estimate of the maximum sustainable catch for the current year in reference to a level of fishing mortality which has an “acceptable level of risk”.
- MEY** - Maximum Economic Yield - the greatest difference between the costs of inputs and the values of outputs (catch). This is the sustained catch that produces the maximum economic value this is usually at a catch below MSY. In the Australian harvest strategy a default B_{MEY} has been set at 1.2 times B_{MSY} .
- MAY** - Maximum Average Yield - which is the long term current annual yield and equivalent to MSY.
- Bo** – The unfished, initial, or virgin recruited biomass for a stock.
- B_{MSY}** – The recruited biomass that supports the maximum sustainable yield.
- B_{MAY}** – The recruited biomass that will support the maximum average yield.
- B_{MCY}** – The recruited biomass that supports the maximum constant yield.
- F_{MSY}** – The fishing mortality rate that, if applied constantly, would result in an average catch corresponding to the MSY and average biomass corresponding to B_{MSY} .
- B_{MEY}** – The recruited biomass that supports the maximum economic yield.
- ESY** – Ecologically sustainable yield – the yield an ecosystem can sustain without shifting to an undesirable state.
- MSY** - Maximum sustainable yield, in relation to any stock, means the greatest yield that can be achieved over time while maintaining the stock's productive capacity, having regard to the population dynamics of the stock and any environmental factors that influence the stock: (section 2, Fisheries Act 1996)

OSY – Optimum sustainable yield is the yield which considers factors in addition to maximum sustainable yield, for instance, effects on other species in the ecosystem and of other human uses of the ecosystem.

Biological reference points can be used to assess the sustainability or state of a stock, for example, the percentage of the unfished population remaining or the portion of eggs or pups produced when compared to the unfished population. In New Zealand quantitative stock assessments the current biomass of a stock is usually compared to the unfished, unexploited or virgin biomass (B_0) (Cordue 2004, Ministry of Fisheries 2008). New Zealand's harvest strategy also includes limits on fishing mortality (eg F_{MSY}).

Reference point catch limits (eg current annual yield (CAY)) rely on agreement as to what constitutes an acceptable level of risk of stock decline below a certain size. These are usually defined in New Zealand stock assessments which state that the biomass should not have the risk of falling below 20% of unfished or virgin biomass (B_0) more than 10% of the time. This is known as the safety condition (Francis 1992 and 1999). As Francis (1999) noted "without this condition, B_{MAY} and B_{MCY} for southern blue whiting are 15% B_0 and 17% B_0 respectively...with the safety condition they are 29% B_0 and 49% B_0 ".

The new harvest strategy sets:

"a specified target about which a fishery or stock should fluctuate; a soft limit that triggers the requirement for a formal, time-constrained rebuilding plan; and a hard limit below which fisheries should be considered for closure" (Ministry of Fisheries 2008a).

However, there are elements of the strategy that may not be consistent with the legislative requirement to keep stocks at or above the MSY level (section 13(2)(a)):

"The harvest strategy standard does not explicitly specify a % B_0 target, and alternative % B_0 targets will be acceptable, provided they can be adequately justified by, for example, considerations of stock productivity. However, it is becoming increasingly difficult to justify stock targets less than 30-40% B_0 (or, equivalently, removing more than 60-70% of the unfished biomass)." (Ministry of Fisheries 2008).

In contrast, the Australian harvest strategy (DAFF 2007) sets a proxy for B_{MSY} at 40% B_0 .

New Zealand sets F_{MSY} as the maximum target of fishing mortality, however the UN Fish Stocks Agreement sets F_{MSY} as a limit to avoid and a point where "fishery management strategies shall ensure that the risk of exceeding limit reference points is very low".

Over-fishing removes more than the estimated sustainable yield, or reduces a stock to below the population size or biomass that supports the maximum sustainable yield (MSY).

Over-fishing can be either recruitment over-fishing or growth over-fishing, or both. Recruitment over-fishing means the current catches are causing a decline in the number of young fish entering the exploited component of a stock, whereas growth over-fishing is reflected in the reduction in the size of the fish being harvested.

The new Ministry of Fisheries (2008a) harvest strategy sets a default soft limit of " $\frac{1}{2} B_{MSY}$ or 20% B_0 , whichever is higher". It also determines that any fishery below the "hard limit" will be designated as collapsed, where the current default hard limit is " $\frac{1}{4} B_{MSY}$ or 10% B_0 whichever is higher". The Australian strategy is more conservative and sets a limit proxy at 20% B_0 when all targeting of a stock should cease (DAFF 2007).

Collapse happened in the Challenger orange roughy fishery off the West Coast, which was closed in 2000 for the 2000/2001 fishing year onwards when the population reached 3% of the unfished

1980 biomass and it remains closed (Wallace and Weeber 2005). Two other orange roughy fisheries have also been closed.

New fisheries create additional challenges. The usual scenario with new fisheries is that they are initially *fished down*⁵ to a level significantly below their unfished biomass (B_0). This can be as low as 20-30% of the unfished biomass where quantitative assessment-based management measures are in place. This process usually removes or substantially reduces the number of older individuals in the population. For example, west coast snapper now has few fish older than 20 years, while in the mid-1970s they represented over 25% of the catch and the maximum age for snapper is about 60 years.

In the conventional *fishing down* process for a fishstock, initial catches may be high as a fraction of the unfished recruited population size, but are not sustainable at this same level in the medium or long-term. This fishing down process can also increase the risk of loss of fish genetic diversity (Smith *et al* 1991, Smith and Benson 1997, and Hauser *et al* 2002). The *Best Fish Guide* does not currently assess the potential loss of genetic diversity.

The main problem with fishing down a stock is that it considers only the sustainable yield of the target stock and not the effect on bycatch species or the overall ecosystem, or the effect of changing environmental conditions. Nor is it precautionary. Often the fishing down of a stock continues well past the target level and ends up reducing the stock size to extremely low levels (such as 3% of B_0 for the Challenger orange roughy fishery). This is often due to the catch limit being set too high based on inadequate information and a lack of precaution. Or it may be due to political decision making linked with industry lobbying to enhance the short-term economic return from New Zealand's fisheries.

Pauly *et al* (1998) has identified the long-term trend of fishing down marine food webs as fishing catch "moves from long-lived, high trophic level, piscivorous⁶ fish towards short-lived, low trophic level, invertebrates and planktivorous fish". Ransom and Worm (2003) identified that fishing by longline has resulted in the depletion of predatory fish species including tunas and sharks.

The impacts of international agreements, or the absence of agreements, on New Zealand caught highly migratory species and straddling stocks is assessed in the management unit and regime criterion (see section 5.6 and table 10).

The National Institute of Water and Atmospheric Research (NIWA 1997) assessed whether catch limits set were risky. They defined risky as the absence of a maximum constant yield (MCY) estimate or when the current total allowable commercial catch (TACC) is at least twice the MCY (excluding fishstocks for which there are current annual yield [CAY] estimates). It is this approach that the *Best Fish Guide* has applied in assessing the status and sustainable yield of individual species.

Scores are applied in the following way:

- From near unfished population size to an over-fished state below 20% of the unfished biomass (B_0) for a stock.
- Where the status of the stock was not reported or highly uncertain the status was recorded as uncertain or unknown and given the next to lowest score.
- Where different stocks of the same species have a different status the worst known state was used.

⁵ "Fishing down" of fish stocks is based on a management approach whereby fish populations are capable of sustaining long-term harvest as a result of compensatory biological responses. Compensation occurs through a reduction in food or space competition from other individuals (density dependent factors) and a biological response through faster growth rates and producing more young than is necessary to maintain the population. The usual result is that the large more fecund fish are removed from the population. This approach leads to fishing down of marine food webs (Pauly and Maclean 2003).

⁶ "Piscivorous" a species feeding preferentially on fish eg tunas and sharks.
"Planktivorous" a species feeding preferentially on plankton eg many pelagic species and most fish larvae.

To better assess the impacts of serial depletion on fish stocks (eg paua) and the impacts of disease events on fish sustainability (eg oysters) the criteria has been modified slightly. The result is to move the assessment of a species down a category if either of these impacts is significant.

Table 2. Score for status and sustainable yield

Score	Status	Stock status
A	Catches well below MSY and stock well above B_{MSY}	A fishstock has potential in the short term to sustain catches higher than those currently taken and there is an agreed pathway to reduced catches to the MSY, CAY and MCY level.
B	Catch limit <MCY	Catches or catch limit less than the estimated MCY based on average catches over a set period (cYav).
B	Catches at or below MSY and stock above B_{MSY}	A fishstock is above B_{MSY} but catches are up to the MSY level based on stock assessment estimate of CAY or MCY.
C	Catch limit or catches >MCY but <2xMCY	Catches or catch limit exceeds the estimated MCY based on average catches over a set period (cYav) but less than twice the estimated MCY.
C	Catch exceeds MSY, CAY or MCY but stock above B_{MSY}	Catch limit or catches exceed MSY but the stock is still above the B_{msy} level, eg, above B_{MAY} or B_{MCY} , whichever is higher and there is no concern about serial depletion or serious disease events.
D	Catch limit or catches greater than twice MCY	Catches or catch limit exceeds twice the estimated MCY based on average catches over a set period (cYav).
D	Stock below B_{msy} but above 20% B_0	The stock has been over-fished and reduced below the size that would support the MSY based on B_{MAY} or B_{MCY} and there is no concern over serial depletion or serious disease events.
D	Uncertain/ unknown yield or stock size	Status and sustainability are unknown due to lack of adequate monitoring data or research. There are no estimates of yield ie MCY, CAY or risk based yields or forward projections. Fisheries operating under such uncertainty are not adopting a precautionary approach and cannot be shown to be sustainable.
E	Stock below 20% B_0	Fishery is over-fished and catches need to be substantially reduced to allow the stock to recover e.g. orange roughy.
E	Stock below B_{MSY} and subject to other factors	Fishery is over-fished and likely below the size that would support the MSY and is subject to either recent low recruitment which would prevent recovery to B_{MSY} within 10 years. Serial depletion (e.g. paua) or recent serious disease events (e.g. dredge oysters).

Note: MSY in this context includes MCY or CAY.

5.2 Fishing method – bycatch and habitat damage

Fishing is the most pervasive direct impact on the marine environment down to depths of 1200 metres or more (Jennings and Kaiser 1998, Hall 1999). The impacts of fishing have a wider footprint than the localised impacts of land originated sedimentation and includes the loss of biodiversity (eg Probert *et al* 1997, Koslow and Gowlett-Holmes 1998, Koslow 2001, Cryer *et al* 2002, Thrush *et al* 2001, Thrush and Dayton 2002, Hiddink *et al* 2006).

The direct effects of fishing include the impact on:

- Non-target species, including bycatch of fish, invertebrates (eg coral and sponges), marine mammals, seabirds and turtles (eg Abraham and Thompson 2009, Baird 2001 2004a, b, c, 2005a, b, c, d, e, Manly *et al* 2002a,b,c, Cryer *et al* 2002). Bycatch can be retained, turned into meal and oil for sale, or discarded. (Discarding QMS species is not allowed unless prior permission is gained).
- Habitat, for example, where fishing gear can damage and remove seabed (benthic) plants and animals such as sensitive sponges, corals, bryozoans (lace corals), and shellfish, which are important settlement surfaces, cover and habitat for other organisms (eg Norse and Watling 1999, Cranfield *et al*, 1999, Cranfield *et al* 2001, Cranfield *et al* 2003, and Cranfield *et al* 2004, Thrush and Dayton 2002, Thrush *et al* 1998 and 2001). Trawling and dredging also can disturb sediment which can smother organisms and block light for algae and seaweeds in shallow water (Committee on Ecosystem Effects of Fishing 2002, Kaiser *et al* 2000, Kaiser *et al* 2001, and Kaiser *et al* 2006).

The indirect effects of fishing are more difficult to assess and measure. These potential changes include alterations to food chains and predator-prey relationships (Jennings and Kaiser 1998 and Symes 1998). Examples of indirect effects include:

- Removal of key/dominant herbivores and carnivores such as snapper, rock lobster, sharks, and paua leading to changes in community structure and a potential reduction in biodiversity or other species (eg, jellyfish or kina) which are less targeted and which may increase beyond their natural stable range;
- The removal of abundant species such as pilchards may impact on natural predators including penguins and other protected or globally threatened seabirds;
- Discarding of unwanted catch may result in changes in food webs and community structure, increasing the abundance of scavengers. It can also attract protected or threatened seabirds, sea lions and seals which are then caught by fishing gear.
- Fishing debris and lost commercial gear can continue to harm marine wildlife for an indefinite period (eg, entanglement), killing protected or globally threatened species of marine mammals and seabirds as well as non-target fish.

Active fishing methods such as dredging and trawling generally have a greater impact on the seafloor than passive techniques such as longlining and gillnetting. The degree of impact caused by various techniques varies with depth, type of seafloor and weight or type of gear used (Collie *et al* 2000). The scale of impact can be substantial. For example, a trawler making three trawl tows of six hours each, using bottom trawl gear with 100 metres between the doors, at an average of three knots, would bulldoze the bottom over an area of about 10 km² (10 trawlers could cover an area greater than the size of Wellington Harbour every day) in one day (Cryer *et al* 2002).

The approach taken in the assessment is consistent with article 6.5 of the UN FAO Code of Conduct on responsible fisheries. This general principle requires:

“6.6 Selective and environmentally safe fishing gear and practices should be further developed and applied, to the extent practicable, in order to maintain biodiversity and to conserve the population structure and aquatic ecosystems and protect fish quality. Where proper selective and environmentally safe fishing gear and practices exist, they should be recognized and accorded a priority in establishing conservation and management measures for fisheries. States and users of aquatic ecosystems

should minimize waste, catch of non-target species, both fish and non-fish species, and impacts on associated or dependent species.”

The destructive impact of bottom trawling and dredging, for example in deepwater and on seamounts, has been highlighted in numerous studies (eg Jones 1992, Dayton *et al* 1995, Thrush and Dayton 2002, Kaiser *et al* 2006 and Gray *et al* 2006).

The impact of trawling on “flat” areas has also been highlighted by a 2002 review of the impact of bottom trawling for scampi, tarakihi and gemfish in 200-600m of water in the Bay of Plenty (Cryer *et al* 2002). Cryer *et al* found a significant impact on a range of benthic biodiversity based on research trawls undertaken over three years. They considered the impact to be indicative of the effects of trawling occurring throughout the fisheries management area.

The area covered by trawling over the whole New Zealand zone is on average around 55,000 square kilometres each year, in middle depth and deep water fisheries between 1990 and 2005 (Ministry for the Environment 2007).

A report by the Marine Conservation Biology Institute (Morgan and Chuenpagdee 2003 and Chuenpagdee *et al* 2003) examined the collateral impacts of different fishing methods in the United States based on a survey 70 participants in fisheries management and a workshop of 13 experts. The report, *Shifting Gear*, was based on responses by marine biologists who ranked the effect of different fishing gear by habitat damage⁷ and the severity of marine damage⁸ including bycatch⁹.

Forest & Bird has reviewed the results of Morgan and Chuenpagdee’s study (2003) to determine whether there were effects which are different in the New Zealand fisheries. Forest & Bird also looked at additional methods which were not assessed in the US study such as collecting and diving, jigging, trolling, hook and line, fyke nets and beach seining. On review an additional criteria to that applied in *Shifting Gear* was added, based on the bycatch of sponges, coral, bryozoans, and other invertebrates. This was to better reflect the full range of species caught as bycatch.

In most cases the rankings were similar to those in the US study (table 3). A noticeable change was the ranking for mid-water trawls which was revised to reflect the impact on globally threatened NZ sea lions, seals and dolphins, and that a proportion of mid-water trawls scrape the seabed (about 50 percent in the hoki fishery). Purse seine was also revised to acknowledge that in the New Zealand zone this method is not known to capture dolphins and other marine mammals.

Each species reviewed in our assessment may be caught by a number of fishing methods, but there is usually a dominant technique. For instance, hoki is caught mainly by trawling. The fishing techniques scored for each species in this assessment are the most common fishing methods used to commercially catch the species in New Zealand. If there was a range of methods used, the fishery was assessed on the basis of the method with the most significant impact.

Scores vary according to the overall impact, the amount of bycatch (non-target catch which is either utilised or discarded) and effect on habitat (minimal impact to substantial damage) (table 4). For example, pelagic longlining for tuna and snapper causes negligible damage to the seafloor but still receives a low score because the technique kills large numbers of seabirds and other bycatch (including sharks), which is generally discarded.

⁷ “Habitat damage” – damage to living seafloor structures (eg corals, sponges, bryozoans) as well as alteration to the geologic structures (eg boulders, cobbles, gravel, sand, mud) that serve as nursery areas, refuges, and homes for fishes and organisms living on or near the seafloor.

⁸ “Collateral damage” – unintentional or incidental damage to sealife or seafloor habitat caused by fishing activities directed toward other types of sea life. Collateral impact includes bycatch and habitat damage.”

⁹ “Bycatch: those species taken in a fishery targeted on other species, or a different size range of the same species and includes that part of the catch that has no commercial value and is discarded alive, injured or dead. Three classes:

Economic bycatch – species discarded because they are of little or no economic value (eg in poor condition or non-marketable);

Regulatory bycatch – marketable species discarded because of management regulations (eg size limits, allocations or seasons);

Collateral mortality – species killed in encounters with fishing gears that are not brought on board the vessel.” (Morgan and Chuenpagdee, 2003, p1)

Table 3. Impacts of different fishing methods

Main Fishing Methods	Habitat impacts		Bycatch						Management Rating	OVERALL RATING
	Physical	Biological	Sponges, corals etc	Shell-fish & crabs	Fin-fish	Sharks & rays	Marine mammals	Sea-birds & turtles		
Collecting and diving	1	1	1	1	1	1	1	1	8	A
Jigging	1	1	1	2	1	1	1	1	9	A
Trolling	1	1	1	1	2	1	2	2	11	B
Purse seining	1	1	1	1	2	2	1	2	11	B
Hook and line	1	1	1	1	3	3	1	2	13	B
Fyke nets	3	2	1	1	2	1	1	2	13	B
Pots	3	2	1	3	2	1	1	2	16	B
Beach seining	3	2	2	3	3	2	1	2	18	C
Longlining – pelagic	1	1	1	1	4	5	2	5	20	D
Gill-nets –mid-water	1	1	1	1	4	4	5	4	21	D
Longlining – bottom	2	2	1	1	4	5	1	5	21	D
Gill net – bottom	2	2	1	1	4	3	5	4	22	D
Trawls – middle-depth	4	3	2	2	3	2	5	3	24	D
Pair trawling	5	5	4	3	4	2	2	2	27	D
Dredging	5	5	5	5	2	2	2	2	28	E
Trawls – bottom	5	5	5	4	5	3	4	3	34	E

Individual characteristic: 1 = very low impact; 5= very high impact;
Overall: A= best; E = worst.

Table 4. Score for fishing method

Score	Technique	Environmental Effects of technique
A	Collecting and Diving eg paua, pipi	Bycatch and wastage: Collecting (usually from the intertidal zone) and diving can be highly selective but not if coastal stripping takes place. Habitat damage: Low habitat impact. Collection and trampling in the intertidal zone may impact on intertidal communities but this is negligible compared to recreational catches which can strip areas of fish and shellfish. Divers are likely to have minimal impact on subtidal habitats.
D if not selective	eg foreshore stripping	
A	Jigging (squid)	Bycatch and wastage: Jigging is highly selective and takes minimal bycatch. Discarded

	eg squid	lines and lost jigs may have an impact on other sea life. Habitat damage: Low habitat impact.
B	Handlining (rod and line and handheld spools) eg snapper	Bycatch and wastage: Non-target and undersized fish are taken as bycatch. Heavy fishing pressure can cause localised depletion of some species. Collection of bait species from the shoreline (eg mussels) can affect inter-tidal communities in some areas. Discarded fishing line and hooks can entangle other marine life. Habitat damage: In shallower areas boat anchors may impact on sensitive habitats.
B	Trapping and Potting Potting – lobster Trapping – blue cod	Bycatch and wastage: Fish traps and lobster pots are selective, with some bycatch of other fish species and octopus. Seals and shags can sometimes be trapped and drown in rock lobster pots and seals and whales and dolphins can get entangled in pot lines. Habitat damage: Minimal habitat damage, unless placed on fragile corals or other reef species.
B	Fyke nets eg freshwater eel	Bycatch and wastage: Fyke nets are selective, with some bycatch of other fish species. Shags can sometimes be trapped and drown in fyke nets. Habitat damage: Minimal habitat damage.
B	Trolling eg albacore tuna	Bycatch and wastage: Trolling is a relatively selective method of catching tuna with few other species being caught. Fur seals and seabirds are occasionally hooked on trolls. Habitat damage: Minimal habitat damage.
B	Purse seining eg kahawai and blue mackerel	Bycatch and wastage: Purse seining usually targets single species schools, and tends to be relatively selective but does catch bycatch fish species. Habitat damage: Negligible impact on the seafloor.
B	Lampara nets eg anchovies, pilchards, and garfish	Bycatch and wastage: Lampara nets usually targets single species schools, and tends to be relatively selective but can catch small fish depending on size of mesh used and target species. Habitat damage: Negligible impact on the seafloor.
C	Beach seining eg yellow-eyed mullet	Bycatch and wastage: Beach seining has low selectivity, which varies with mesh size. Habitat damage: It may impact on sensitive areas.
C-D	Danish seining eg snapper	Bycatch and wastage: Similar to beach seining but carried out in deeper water with the catch hauled on deck. The catch is more likely to be crushed and survival of discarded catch is lower than beach seining. Habitat damage: Danish seine nets contact seafloor. While mostly carried out on sandy and

		low profile seafloor, it can impact on sensitive and vulnerable seabed habitat.
D	Longlining <i>Pelagic</i> – tuna, snapper <i>Bottom-set</i> – ling and bluenose <i>Droplines</i> – bluenose	Bycatch and wastage: Longlining for tuna results in significant mortality of albatrosses and petrels as well as billfish and sharks. Inshore longlines set for species such as snapper also catch and kill petrels. Habitat damage: It has minimal impact on habitat but lost lines can entangle and kill protected marine wildlife. Longlining uses a large amount of bait, potentially affecting these species and raising biosecurity issues over the environment into which the bait is released.
D	Drag net eg flat fish	Bycatch and wastage: Drag net has low selectivity, which varies with mesh size. Habitat damage: It may impact on sensitive areas.
D	Gillnetting (including set netting) eg rig shark, elephant fish	Bycatch and wastage: Gillnetting(including set netting) has the potential to take large amounts of bycatch including dolphins, seals, sharks, seabirds and reef fish. Longer soaking periods lower the chance of unwanted fish being released alive. Habitat damage: Minimal impact on the seafloor.
D	Middle-depth trawling eg hoki, squid, and southern blue whiting	Bycatch and wastage: Can take substantial tonnage of bycatch. Trawling catches fur seals, sea lions and dolphins. Habitat damage: If the seabed is not touched then impact is minimal, however pelagic trawls often touch the bottom and therefore have similar impacts to bottom trawling.
E	Bottom trawling and dredging, including pair trawling <i>Trawling:</i> eg orange roughy. <i>Dredging:</i> eg oysters, scallops	Bycatch and wastage: Trawling and dredging can take large quantities of bycatch including fish and invertebrate species, eg sponges, corals etc. Bycatch in some trawling and dredging can be up to 10 times the target species. Trawling also catches fur seals, sea lions and dolphins. Habitat damage: Gear dragged along the seafloor may cause major habitat damage, increases turbidity and alters substrate topography. Dredging is particularly damaging to benthic species ¹⁰ .

5.3 Biology and risk of over-fishing

The life span, age at sexual maturity, fecundity (number of eggs or young produced), productivity and level of natural mortality are all factors that determine the susceptibility of a species to the effects of fishing, including how quickly it will recover from over-fishing. In addition, the geographic distribution, degree of endemism (whether it is restricted to one area or widely distributed), behaviour and social structure of a species (whether it is solitary, territorial, highly migratory or site specific) also contribute to how a species responds to commercial exploitation.

¹⁰ Benthic species or benthos - animal or plants living on the bottom of the ocean.

In general, species that live for a long time (50 years plus), mature late (15 years plus) and have low fecundity and low natural mortality are most at risk from the impacts of fishing. Examples include orange roughy, oreos and various sharks. These characteristics make them more susceptible to the impacts of fishing than a short-lived species such as squid that produces a large number of eggs. Sharks are vulnerable in particular because of the small number of live pups produced. For example, mature female school sharks produce only 17-41 pups, while mature female spiny dogfish produce only 2-17 pups (Cortes 2002).

In species that are slow to mature, the effects of fishing may not be seen until it is too late to reverse them. Fish which exhibit aggregating or schooling behaviour (for feeding or spawning) are also easily targeted by commercial fishing vessels that can take large catches in a short time eg orange roughy. Likewise, fish such as blue cod change sex, with the largest individuals being male and therefore size limits may not protect the total population¹¹.

Short-lived highly productive species such as squid or anchovy which live for one or a few years can sustain a larger proportion of their population being taken each year. Their populations will fluctuate much more than slow growing long lived multi-year class species, such as orange roughy or school shark. Long lived low productivity, low fecundity species such as sharks or orange roughy can only sustain having a small proportion taken each year.

A number of researchers have looked at the extinction risk facing fish species (Musick 1999c, Musick *et al* 2000a and Musick 2000b). Musick (1999c) proposed criteria designed to identify fishstocks which could be at risk so that action can be taken in the early stage of decline to avoid listing species as threatened with extinction. In addition to the categories developed by Musick and others for the American Fisheries Society (Musick *et al* 2000a and Musick *et al* 2000b) a new category for species with very high resilience has been added so as to give a five point risk rating for each species and make these criteria consistent with other criteria (table 5).

Table 5. Population resilience and productivity parameters

Population resilience	Productivity parameter						Risk Rating
	Intrinsic rate of increase (r)/yr	von Bertalanffy (k)	Fecundity per year	Age at maturity (T _{mat})	Max age (T _{max})	Natural Mortality ¹² (M)	
Very High	>1	>0.60	>10 ⁵	<1	<1	>0.4	A
High	1-0.51	0.31-0.60	10 ⁴ -10 ⁵	1-2	2-3	0.2-0.4	B
Medium	0.16-0.50	0.16-0.30	10 ² -10 ³	2-4	4-10	0.1-0.2	C
Low	0.05-0.15	0.05-0.15	10-10 ²	5-10	11-30	0.05-0.1	D
Very low	<0.05	<0.05	<10	>10	>30	<0.05	E

Appendix II sets out key biological information on commercial fish species and includes an estimate of a species resilience or risk rating.

As in Musick *et al* (2000a), fishstocks may be classified according to any of the criteria with intrinsic rate of increase being the key factor. The stock should be assessed according to the lowest productivity parameter for which data are available in table 5. For example, a stock with high

¹¹ Size limits are usually designed to protect immature fish but they can also ensuring that the species spawns at least once prior to reaching the size limit or to enhance the value of the catch (Hancock (ed) 1992).

¹² Natural mortality has been added for comparison with von Bertalanffy r and k.

fecundity (>10⁴), but late maturity (5-10 years) and long life span (>30 years), would be classified under the very low productivity category.

In addition to the productivity risk to a stock there are a number of other factors to consider:

- Rarity;
- Small range and whether the stock is endemic to New Zealand eg longfin eels or blue cod;
- Specialised habitat requirements such as coral reef beds or seagrass beds;
- Specialised requirements for settlement of larvae and limited larval movement eg oysters, scallops or paua;
- Population decline, including size and speed of decline;
- Loss of habitat, especially on species with a small range and specialised habitat requirements.

These categories have been used to assess a fishery's potential risk (table 6). The biology of each species is scored from A to E – from most resilient to fishing, to least resilient based on life-span, time to maturity, reproductive output, and schooling or biological behaviour.

Table 6. Score for biology and risk of over-fishing

Score	Notes
A <i>(Very resilient to fishing)</i>	Abundant, fast to mature, produce large number of eggs/young, short life span, capable of sustaining large catches over extended periods, eg, arrow squid, anchovies.
B	Reasonably abundant and fast growing with high reproductive capacity, mostly pelagic, eg, red cod and red gurnard.
C <i>(Moderately resistant to fishing)</i>	Vulnerable to over-fishing because of one or a number of the following factors: relatively late onset of sexual maturity, low fecundity, slow growing, aggregate (eg, when spawning) or form schools, long-lived, limited habitat of distribution, or limited settlement requirements eg, elephant fish.
D	Key biological information is unknown (including age, age at recruitment and mortality, natural mortality, biological parameters (Von Bertalanffy etc).
D	Very vulnerable to over-fishing because of a number of the following factors: late onset of sexual maturity, low fecundity, slow growing, aggregate (eg, when spawning), or form schools, long-lived, limited habitat of distribution, highly variable recruitment, or very specialised settlement requirements eg, school shark or rig,
E <i>(Least resilient to fishing)</i>	Unlikely to sustain exploitation beyond a very low level. Late onset of sexual maturity, few young, and/or rare, limited habitat/range, eg, orange roughy or oreos.

5.4 Management and research

Fisheries managers rely on accurate research-based stock assessments to develop management regulations, including catch limits, to manage fishstocks well. Regulations include input controls such as seasonal closures, size limits and gear restrictions (trawl mesh size, length of gill nets) and output controls such as total allowable catches.

The New Zealand Ministry of Fisheries runs an annual fisheries stock assessment process. For some species, where stock assessment models are used, forward projections are undertaken to assess how the stock might respond to future catch levels (Annala *et al* 2003, Sullivan 2003 and 2005, Sullivan *et al* 2005). Examples include hoki, orange roughy and oreo stocks.

Determination of stock status and sustainable yield relies principally on obtaining accurate information from individual fishers over many years. This requires assumptions about the accuracy of the reporting of catches, extent of the fishing effort, and the location of fisheries. Poaching, illegal catches, inaccurate and false reporting, and discarding complicates any assessment¹³. The wrong species may be reported or the reporting code may result in several species being reported together, for example, flatfish.

Fisheries scientists therefore look for fisheries independent sources of information. These include random trawl surveys, acoustic surveys and tagging surveys. In addition, the presence of independent scientific observers on board vessels ensures additional biological information is collected and provides a baseline check against the accuracy of commercial fishers' reporting, including information on bycatch (both fish and non-fish).

In New Zealand independent scientific observer coverage is very low in inshore fisheries (less than one percent) and is usually low, with observer bias problems, in middle depth and deepwater fisheries (for example, oreos, orange roughy or hoki).

Most fisheries are managed based on commercial fishing returns such as catch effort returns or catch per trawl, longline set or pot-lift. Fisheries independent monitoring and research is therefore very minimal. The commercial return from many fisheries have until recently only provided effort information within large statistical areas and the actual position of the fishing effort (e.g. inshore trawl, pot-lift or longline set) is not reported, for example, on catch landing returns in the many inshore fisheries¹⁴. It will be several years until this more detailed reporting system can be used to inform stock assessments.

Sustainable yields are usually calculated solely based on catch effort reports. This information provides little certainty on the long-term ecological sustainability of any fishery. A critical flaw is that in order to estimate yields in fisheries models a fishstock has been historically required to be "over-fished" and the population reduced to low levels to provide contrast in the data used in any stock assessment. This is not consistent with a precautionary approach to ecologically sustainable fisheries.

Setting the total allowable catch (TAC) for a specific stock is divided up into total allowable commercial catch (TACC), recreational and customary catch, and all other fishing related mortality (such as illegal catch, bycatch, and incidental catch)¹⁵. Other fishing related mortality is poorly estimated when used and is not estimated in most fisheries. This means that the effect of discards and high grading (discarding lower value species or size class for one of higher value) is not considered, especially in fisheries where there is no independent scientific observation of effort.

Essential fishery information to manage a stock includes:

- fish life-history and habitat requirements, for example, maximum age, natural mortality, age at reproductive maturity (Paul 1992);
- the status and trends of fish populations, fishing effort and catch levels;

¹³ Examples of mis-reporting include hake 7 as hake 4, under-reporting of hake (700-1000t/yr) and ling (250-400t/yr), silver warehou bycatch in the west coast hoki fishery, and estimated annual illegal catches of paua (400 tonnes) and rock lobster (230 tonnes) (Annala *et al* 2003, Dunn 2003, Sullivan *et al* 2005).

¹⁴ Catch landing returns (CLR) only reports within large statistical areas and individual effort (eg trawls) are not reported separately. The alternative total catch effort processor return (TCEPR) is filled out by the larger trawlers. The current reporting system needs to be modified to ensure each individual unit of effort is reported separately.

¹⁵ Section 13 of the Fisheries Act set out the provisions for setting the total allowable catch so that it "(a) Maintains the stock at or above a level that can produce the maximum sustainable yield, having regard to the independence of stocks".

- fishery effects on fish age structure and other marine living resources;
- climate variability effects on larval and juvenile survival and growth.

Some of this essential fisheries information is set out in Appendix II.

Forest & Bird found that information on commercially exploited fish populations is patchy at best. In low commercial value stocks basic biological information such as maximum age, growth rates and age at maturity is often missing. The use of inaccurate or poor information in fisheries models and the setting of catch limits can lead to erroneous decisions being made. For example, most fish are aged by counting rings in ear bones (otoliths) but this requires validation to confirm whether the rings are annual, seasonal or daily rings (Neil *et al* 2004). This has not been achieved for a number of species. In some species annual rings laid down in vertebrae or scales can be used to age fish.

Stock assessments in New Zealand are usually based on a single species with little consideration of any other species caught and killed by fishing activity or of the rest of the marine ecosystem. The effect of climatic factors on fish productivity and larval and juvenile survival is ignored in most assessments. In some species, such as arrow squid, red cod or red gurnard, the survival of larvae and young depends on oceanographic and environmental conditions.

The specific environmental factors are usually not fully understood but many species seem to respond to La Nina/El Nino changes. For example, snapper has good recruitment in warm La Nina years and poor recruitment in cooler El Nino years, while hoki, red cod and red gurnard tend to follow the opposite trend (Beentjes and Renwick 2001; Bull and Livingston 2001, Gilbert and Taylor 2001).

New Zealand has yet to develop a system of ecosystem assessments to allow for ecosystem-based oceans planning and management. Yet, it is widely recognised that the impact of fishing is the most pervasive impact on the marine environment (eg Norse and Watling 1999, Symes 1998, Thrush and Dayton 2002, Dayton *et al* 2002).

Overall, effective management is more than just collecting catch and biological information on each fish species. The impact of non-commercial fisheries must also be considered. The tendency for short-term economic objectives to over-ride environmental considerations means that New Zealand has some way to go to achieve ecologically sustainable fisheries.

The following management and research factors are considered as important elements of an ecologically sustainable management and research system and against which the management of a species should be compared:

- Annual quantitative stock assessments and setting catch limits on the basis of best assessments and use of precautionary principle;
- Appropriate biological reference points or trigger points or bottom-line standards identified (ie, indicators against which the status of a stock can be judged);
- Formal management plans and strategies based on the knowledge of species and stocks;
- Sound basic biological knowledge of the species including natural mortality, age at recruitment, age at maturity and maximum age;
- Adequacy of recent research, including independent at sea observation and monitoring, and the use of fishery independent methods, eg, random trawl surveys, tagging or acoustic methods.

International management is included in the next criteria assessing management unit. The following scores (A to E) have been developed for the overall management and research assessment of New Zealand's commercial marine fisheries (table 7). Stocks were rated on the basis of the five management and research factors set out above.

Table 7. Scores for Management and research

Score	Notes
A	All five of the above elements present.
B	3 or 4 elements present including basic biological information, biological reference points and regular stock assessments
C	2 or 3 elements present including basic biological information and biological reference points
D	1 or 2 elements present
E	None of the elements present.

5.5 Protected species or threatened species bycatch

All marine mammals and seabirds, and three marine species (black spotted groper and black and red coral), are protected under the Wildlife Act and the Marine Mammals Protection Act. The IUCN – International Union for the Conservation of Nature and Natural Resources – and the Department of Conservation (DoC) list a range of threatened species (IUCN 2001a, b, Molloy *et al* 2002, Hitchmough 2002, Musick 1999c, BirdLife International 2000 and 2004, see www.redlist.org). While the marine species assessed are predominantly marine mammals and seabirds there has been a move in the last seven years to determine the threat status of other marine species including certain sharks and corals.

There is a myth that marine species are not vulnerable to extinction (Mace and Hudson, 1999). Certain marine species exhibit a wide range of life histories, including restricted geographic range and low reproductive output, which make them vulnerable to extinction. Long-lived marine species generally have slow growth, late maturity, and low fecundity and variable year class strengths which can survive to maturity (Musick 1999a).

Both IUCN and the Department of Conservation have assessed a range of marine species using slightly different criteria (table 8), for example southern bluefin tuna is currently assessed as critically endangered and the Pacific bigeye stock as endangered.¹⁶

The IUCN shark specialist group has assessed all the sharks of Australasia such as school shark which is listed as Vulnerable in Australia and Near Threatened in New Zealand (Cavanagh *et al* 2003).

Table 8. IUCN and Department of Conservation Threatened species categories

Chance of extinction	Decline in population	Threat Category	
		IUCN (International)	DoC Equivalent (National)
>50% in 10 years or 3 generations	80% decline in 10 years or 3 generations	Critically Endangered	Nationally Critical
>20% in 20 years or 5 generations	50% decline in 10 years or 3 generations	Endangered	Nationally Endangered; Nationally Vulnerable, Serious decline
>10% in 100 years	20% decline in 10 years or 3 generations	Vulnerable	Gradual decline; At Risk: range restricted or sparse

=<10% in 100 years	<20% decline in 10 years or 3 generations	Near-Threatened	No category
Insufficient data	Insufficient data	Data Deficient	Data Deficient
Much less than 10% in 100 years	Much less than 20% decline in 10 years or 3 generations	Least Concern	Not Threatened

References: IUCN 2001, Molloy et al 2002

In the absence of Ministry of Fisheries or Department of Conservation observers there is poor reporting of protected species and threatened species deaths in fisheries. Even with observers on board, captures of non-target benthic species such as corals, sponges, and bryozoans can be inadequate.

Appendix IV and V sets out some of the available information on reported seabird and marine mammal captures in observed fisheries. Appendix VI lists the turtle species reported caught in observed fisheries.

Under the UN FAO Code of Conduct on Responsible Fisheries (FAO 1995b), International Plans of Action (IPOAs) have been developed for:

- Reducing Incidental Catch of Seabirds in Longline Fisheries,
- Conservation and Management of Sharks, and
- Management of Fishing Capacity (FAO 1999a).

The IPOAs were adopted by the twenty-third Session of the FAO Committee on Fisheries (COFI) in February 1999 (FAO 1999b) and endorsed by the FAO Council at the session it held in November 2000.

New Zealand released its voluntary National Plan of Action on seabird captures in fisheries (MFish and DoC 2004) and is currently reworking the final redraft with stakeholders.

In 2008, a National Plan of Action – Sharks was developed, but this maintained the legal practice of shark finning and did little other than condone the status quo management of sharks in New Zealand. Unlike Australia and the United States, New Zealand does not ban the finning of sharks at sea.

The Convention on the Trade in Endangered Species (CITES) listed a number of marine species at its last three meetings. Whales, dolphins, seals, marine turtles and some corals which are caught by different fishing methods are listed (see Appendix III). The Convention on Migratory Species (CMS) has listed a number of marine species, including all 27 species of albatross and petrel threatened with extinction by longline fishing. New Zealand has signed and ratified the Agreement on the Conservation of Albatrosses and Petrels (ACAP) developed under the CMS which entered into force internationally in February 2004.

Basking shark is one species listed by both the CMS and CITES. This Vulnerable threatened shark is caught in a range of trawl fisheries including the squid and hoki fisheries. See Appendix III for list of marine species covered by CMS, CITES or ACAP listing.

The scores A to E were set to indicate the risk posed by fishing (including commercial bycatch species) to species globally threatened with extinction (table 9). For example, for an endangered or critically endangered species the threshold has been set at zero.

Table 9. Scores for protected species or threatened species bycatch

Score	Note
A	Fishery catches no protected species or threatened species bycatch.
B	Fishery catches less than 10 per annum of non-threatened protected species.
C	Fishery catches less than 20 per annum of non-threatened protected species or catches non-threatened species.
D	Fishery catches vulnerable or near-threatened species or catches large numbers of protected species over 20 per annum but less than 100 annually.
E	Fishery catches endangered or critically endangered species.
E	Fishery catches more than 100 threatened or protected species annually.

When applying scores to individual seafood species, changes in fisheries management, such as a reduction in bycatch as a result of avoidance or mitigation requirements and practices, are taken into consideration based on the best available information.

5.6 Management unit and management regime

This criteria assesses the management unit used to manage fish species in New Zealand and the effectiveness of management for straddling stocks and highly migratory species caught in New Zealand waters.

Under both quota management and non-quota management several species can be managed as one quota group. For example, three oreo species are managed as one unit despite different biological characteristics and depth ranges (Appendix II), and eight flatfish species are managed as one unit. While most flatfish are fast growing and short-lived (3-6 years) recent studies have shown that brill and turbot (currently managed within the same quota management unit) live longer, reaching a maximum age of 21 years and 16 years respectively (Stevens *et al* 2001).

An additional risk can be the management of several stocks as one quota or fisheries management area. Separate stocks are considered to be separate breeding populations. Managing several stocks together can lead to one stock, particularly the smaller stock, being over-exploited. For example, the two hoki stocks in New Zealand are managed as one quota unit.

For some species there is an added risk of serial depletion if the stock unit is a small geographical unit as in the case of cockles and paua (McShane and Naylor 1995). The quota management species have usually had catch limits established for large areas which do not take into account the potential for serial depletion of discrete sub-units (such as spawning populations). In many cases the species stock structure and boundaries are unknown (e.g. anchovy).

For highly migratory species (eg tunas) or straddling stocks (e.g. Challenger orange roughy) the New Zealand EEZ only includes part of the fisheries range so the status of any international management regime needs to be considered (see Appendix V). For straddling stocks not covered by the Western and Central Pacific Tuna Commission or the Commission on the Conservation of Southern Bluefin Tuna (CCSBT) there is no finalised international management and no international catch limits are set. Limited interim measures exist for some species not covered by the tuna agreement (eg orange roughy and jack mackerel) under the negotiations to develop a South Pacific Regional Fisheries Management Organisation (SPRFMO). Even where there is international management there is often not the commitment to take action required to reduce catch limits to sustainable levels (eg CCSBT for southern bluefin tuna) or there may be a high level of illegal, unauthorised or unregulated fishing (IUU) (eg toothfish under the Commission on the Conservation of Antarctic Marine Living Resources - CCAMLR). New Zealand adopted a national plan of action on IUU fishing in June 2004 (<http://www.fish.govt.nz/current/iuu-fishing/iuu-fishing.pdf>).

Since 2005, the assessment criteria have taken into account the management of straddling stocks and highly migratory species. This includes whether there is a convention or agreement for this species and whether it is taking effective action, and whether there is significant IUU activity.

The scores A to E were set to indicate the risk posed by managing multiple species as one unit or not dividing stocks into different management areas, or the management of highly migratory species or straddling stocks (table 10).

Table 10. Scores for management unit

Score	Note
A	Fishery is managed by individual species, stocks are divided into different management units (quota or fisheries management areas) and there is no risk of serial depletion.
A	There is an international agreement which well manages highly migratory species or straddling stocks, sets precautionary catch limits and there is a low level of IUU catches.
B	Fishery is managed by individual species, stocks are divided into different management units but there is a low risk of serial depletion of discrete sub-units (eg spawning populations).
B	There is an international agreement which well manages highly migratory species or straddling stocks, sets precautionary catch limits but despite comprehensive measures to eliminate IUU catches they continue at a moderate level.
C	Fishery is managed by individual species but two stocks are managed as one management unit and any other stocks are managed separately or management boundaries do not match stock boundaries.
C	Fishery is managed by individual species but stock structure is unknown or highly uncertain but there is a low risk of serial depletion.
C	There is strong interim arrangement which sets precautionary catch limits and there is substantial progress towards an international agreement which will manage highly migratory species or straddling stocks.
C	There is an international agreement which sets precautionary catch limits for highly migratory species or straddling stocks, but there are only limited measures to eliminate IUU catches and they continue at a moderate level.
D	Fishery is managed by individual species but more than two stocks are managed as one management unit.
D	Fishery is managed by individual species but stock structure is unknown but it is managed by fisheries management areas and there is a high risk of serial depletion of discrete sub-units (eg spawning populations).
D	There is a weak interim arrangement but there is a commitment to develop an international agreement to manage highly migratory species or straddling stocks.
D	There is an international management regime to set conservation measures for the species but it has yet to apply any sustainable catch limits or catch limits are not sustainable (CCSBT) or the agreement

	represents only a small part of the catch and there is a high level of IUU fishing.
E	More than one species are managed as one fishery (eg oreos, groper,).
E	More than one species are managed as one fishery and stock structure is unknown.
E	There is no international management regime or interim measures (eg alfonsino).

All schemes: A= Best; E = Worst

Appendix I

Major Commercial Fish Species

Trawl Fisheries	Dredge fisheries
Northern Inshore trawl	Dredge oyster (<i>Tiostrea chilensis</i>)
Snapper (<i>Pagrus auratus</i>)	Scallop (<i>Pecten novaezelandiae</i>)
John dory (<i>Zeus faber</i>)	Longline Fisheries
Tarakihi (<i>Nemadactylus giganteum</i>)	Demersal Longline fisheries
Trevally (<i>Pseudocaranx dentex</i>)	Snapper (<i>Pagrus auratus</i>)
Jack mackerel (<i>Trachurus novaezelandiae</i> , <i>T declivis</i>)	Other longline fisheries
Barracouta (<i>Thyristes atun</i>)	Ling (<i>Genypterus blacodes</i>)
Red gurnard (<i>Chelidonichthys kumu</i>)	Bluenose (<i>Hyperglyphe antarctica</i>)
Southern inshore trawl	Hapuku (<i>Polyprion oxygeneios</i>)
Red cod (<i>Pseudophycis bachus</i>)	Bass (<i>Polyprion americanus</i>)
Red gurnard (<i>Chelidonichthys kumu</i>)	School shark (<i>Galeorhinus australis</i>)
Flatfish (<i>Rhombosolea leporina</i>)	Pelagic longline (tuna)
Blue cod (<i>Parapercis colias</i>)	Southern blue fin (<i>Thunnus maccoyii</i>)
Northern middle depth trawl	Bigeye tuna (<i>Thunnus obesus</i>)
Gemfish (<i>Rexea solandri</i>)	Albacore (<i>Thunnus alalunga</i>)
Hoki (<i>Macruronus novaezelandiae</i>)	Yellowfin tuna (<i>Thunnus albacares</i>)
West Coast & Chatham Rise Middle depth trawl	Swordfish (<i>Xiphias gladius</i>)
Hoki (<i>Macruronus novaezelandiae</i>)	Purse seine
Hake (<i>Merluccius australis</i>)	Kahawai (<i>Arripis trutta</i>)
Ling (<i>Genypterus blacodes</i>)	Skipjack tuna (<i>Katsuwonus pelamis</i>)
Silver warehou (<i>Seriolella punctata</i>)	Trevally (<i>Pseudocaranx dentex</i>)
Southern Middle depth trawl	Blue mackerel (<i>Scomber australasicus</i>)
Arrow Squid (<i>Nototodarus sloanii</i>)	Set Net fisheries
Barracouta (<i>Thyristes atun</i>)	Rig (<i>Mustelus lenticulatus</i>)
Hoki (<i>Macruronus novaezelandiae</i>)	School shark (<i>Galeorhinus galeus</i>)
Hake (<i>Merluccius australis</i>)	Butterfish (<i>Odax pullus</i>)
Ling (<i>Genypterus blacodes</i>)	Grey mullet (<i>Mugu cephalus</i>)
Silver warehou (<i>Seriolella punctata</i>)	Potting fisheries
Sub-Antarctic middle depth trawl	Red rock lobster (<i>Jasus edwardsii</i>)
Arrow Squid (<i>Nototodarus sloanii</i>)	Blue cod (<i>Parapercis colias</i>)
Southern blue whiting (<i>Micromesistius australis</i>)	Diving - Paua
Hake (<i>Merluccius australis</i>)	Paua (<i>Haliotis iris</i> and <i>H. australis</i>)
Ling (<i>Genypterus blacodes</i>)	
Deepwater trawl (over 750m)	
Orange roughy (<i>Hoplostethus atlanticus</i>)	
Smooth oreo (<i>Pseudocyttus maculatus</i>)	
Black oreo (<i>Allocyttus niger</i>)	
Black cardinal fish (<i>Epigonus telescopus</i>)	
Scampi trawl	
Scampi (<i>Metanephrops challengerii</i>)	

Appendix II

Key Biological Indicators of Fish Species

Where: e = endemic
 s = sharks, rays and relatives
 ? = unknown
 number? = uncertain
 number?? = very uncertain

Common name	Scientific name	Age when mature	Maximum age	Age when first fished	M - natural mortality	Von B growth k	Risk rating
Albacore tuna	<i>Thunnus alalunga</i>	6-8	20?	2	0.34	0.0347	C?
Alfonsino	<i>Beryx splendens</i> and <i>B. decadactylus</i>	4-5 ?	17 ?	4-5 ?	0.23 ?	0.08- 0.11 ?	C?
Anchovy	<i>Engraulis australis</i>	1	6	2	?	?	A?
Antarctic toothfish	<i>Dissostichus mawsoni</i>	8-10?	48+	5-7	0.13	0.090	D
Arrow squid	<i>Nototodarus sloanii</i> <i>N. Gouldi</i>	22-30 cm ML	1? 1?	? ?	? ?	2.1-3.6 2-2.8	Ae A
Barracouta	<i>Thyrstites atun</i>	2-3	10+	3?	0.3	0.45?	B
Bigeye tuna	<i>Thunnus albacares</i>	3	11+	2	0.4	0.226	C
Black cardinal fish	<i>Epigonus telescopus</i>	35-45	100+	35	0.034 ?	0.034	E
Blue cod	<i>Parapercis colias</i>	2-6	32	2	0.14	0.1-0.4	Ce
Blue mackerel	<i>Scomber australasicus</i>	2	24	3	0.2?	0.15	C
Blue moki	<i>Latridopsis ciliaris</i>	5-6	43	5	0.1?	0.208	D?
Blue shark	<i>Prionace glauca</i>	7-9	22	5	0.19- 0.21	0.165M 0.2297 F	Ds
Blue warehou	<i>Seriotelella brama</i>	4-5	22	4	0.24	0.169	C
Bluenose	<i>Hyperoglyphe Antarctica</i>	10	60+	?	0.08	?	D
Broadbill swordfish	<i>Xiphias gladius</i>	5-10	18+	4?	0.22	?	C?
Butterfish	<i>Odax pullus</i>	2-4?	11- 15?	2-3	0.3- 0.45	0.23	C
Cockles	<i>Austrovenus stutchburyi</i>	1	8+	3?	0.19- 0.5	0.311- 1.10	B
Dark ghost shark	<i>Hydrolagus novaezealandiae</i>	?	?	?	?	?	D?s
Eel – longfin	<i>Anguilla dieffenbachia</i>	11-56	106	8-17	0.036 ?	?	Ee
Eel – shortfin	<i>Anguilla australis</i> , <i>A. reinhardtii</i>	5-41 ?	60 ?	6-13 ?	0.038 ? ?	? ?	E
Elephantfish	<i>Callorhynchus milii</i>	3-5	9-15	3+	0.35	0.060- 0.473	C

Common name	Scientific name	Age when mature	Maximum age	Age when first fished	M-natural mortality	Von B growth k	Risk rating
Flatfish – Yellow-belly flounder Sand flounder/Dab Black flounder Greenback flounder Lemon sole NZ sole Brill Turbot	<i>Rhombosolea leporina</i>	?	?	?	?	?	?e
		2-3	6?	2	1.1- 1.3	.235- .781	Ae
	<i>R. plebeia</i>	?	?	?			?e
	<i>R. retiaria</i>	?	?	?	?	?	?e
	<i>R tairina</i>	?	?	?	?	?	Ae
	<i>Pelotretis flavilatus</i>	?	?	?	0.62- 0.96	1.29- 1.85	?e
	<i>Peltorhamphus novaezealandiae</i>	?	21	?	?	?	Be
	<i>Colistium guntheri</i>	?	16	?	0.20		B
						0.1- 0.37	
						0.34- 0.39	
Frostfish	<i>Lepidopus caudatus</i>	?	8?	?	0.58?	?	B?
Garfish	<i>Hyporhamphus ihi</i>	2-3	10?	2-3?	0.5?	?	Be
Gemfish	<i>Rexea solandri</i>	3-6	17	3-5	0.25	0.114- 0.295	D
Grey mullet	<i>Mugil cephalus</i>	3	15	5	<0.33	0.587- 0.619	B
Green-lipped mussel	<i>Perna canaliculus</i>	1	?	1?	?	?	?
Groper – hapuku bass	<i>Polyprion oxygeneios</i>	10-13 10?	60+ 40+	5 5?	<0.1 <0.1?	?	D D
	<i>P. americanus</i>						
Hake	<i>Merluccius australis</i>	6-10	25	2	0.18- 0.2	0.220- 0.357	C
Hoki	<i>Macruronus novaezealandiae</i>	4+	20-25	2	0.25- 0.3	0.161- 0.261	C
Jack mackerel - Peruvian	<i>Trachurus declivis</i> ,	2-4	25+	2-3	0.18	0.28	C
	<i>T. novaezealandiae</i> ,	3-4	25+	?	0.18	0.30	C
	<i>T. symmetricus murphyi</i>	4?	32?	2?	0.3?	0.155	C?
John dory	<i>Zeus faber</i>	2-3	12	2-3	0.38	0.425- 0.480	B
Kahawai	<i>Arripis trutta</i>	3-4	26	3-4?	0.18	0.23- 0.34	C
Kina	<i>Evechinus chloroticus</i>	4-5	20+	8-9?	0.2??	?	C?
Kingfish	<i>Seriola lalandi</i>	4-7?	16+?	2-4?	0.20- 0.25	0.119F- 0.137M	C?
Leather jacket	<i>Parika scaber</i>	2	7+?	?	0.6??	?	B?
Ling	<i>Genypterus blacodes</i>	5-9	30	5	0.18	0.067- 0.194	C
Lookdown dory	<i>Cyttus traversi</i>	?	30+	?	0.15?	?	C?

Common name	Scientific name	Age when mature	Maximum age	Age when first fished	M -natural mortality	Von B growth k	Risk rating
					?		
Mako shark (shortfin)	<i>Isurus oxyrinchus</i>	7-9M 19-21F	29+	7?	0.10-0.15	0.0524 M 0.0154 F	Ds
Moonfish	<i>Lampus gutatus</i>	4-5	14+	2-4	0.20-0.25	?	B
Scallops	<i>Pecten novaezelandiae</i>	2	6-7	2-3	0.21-0.5	0.378-1.7?	B
Orange roughy	<i>Hoplostethus atlanticus</i>	23-29	120-130	23-29	0.045	0.061-0.070	E
Oreos – black, smooth, Spiky	<i>Allocyttus niger</i> , <i>Pseudocyttus maculatus</i> <i>Neocyttus rhomboidalis</i>	27 31 ?	153 86 100+	27? 21 ?	0.044 0.063 ?	0.05 0.047- 0.067	E E E?
Oysters (dredge)	<i>Tiostrea chilensis</i>	3-4	36+	4-8	0.075	0.48	D?
Packhorse lobster	<i>Jasus verreauxi</i>	?	?	?	?	?	D?
Pacific bluefin tuna	<i>Thunnus orientalis</i>	3-6	20+	3+	0.1-0.3	0.1035-0.211	D
Paddle crabs	<i>Ovalipes catharus</i>	3-4?	?	3-4?	?	???	B?
Pale ghost shark	<i>Hydrolagus bemisi</i>	?	?	?	??	?	D?s
Parore	<i>Girella tricuspidata</i>	4-5	10+	4?	?	?	C
Patagonian toothfish	<i>Dissostichus eleginoides</i>	8-10	50+	8	0.13	0.067?	D
Paua	<i>Haliotis iris</i> , <i>H. australis</i>	3-5? ?	? ?	5-8+ ?	0.02-0.25	0.20-0.34 ?	E
Pilchards	<i>Sardinops sagax (neopilchardus)</i>	2	9	2	0.46-0.66	?	A
Porae	<i>Nemadactylus douglasii</i>	?	30+	8	0.15? ?	?	D
Porbeagle shark	<i>Lamna nasus</i>	8-11M 15-18F	65?	1+	0.05-0.10?	0.112-0.060?	Es
Queen scallops	<i>Zygochlamys delicatula</i>	4 M, 5F	10+	3-5	?	0.187	C
Rays bream	<i>Brama brama</i>	3-5	25+?	?	0.2???	?	D?
Red cod	<i>Pseudophycis bachus</i>	2-3	7?	2	0.76	0.41-0.53	B
Red gurnard	<i>Chelidonichthys kumu</i>	2-3	16	2	0.29-0.35	0.25-0.641	B
Red snapper	<i>Centroberyx affinis</i>	?	40-80?	?	0.1???	?	D?
Ribaldo	<i>Mora moro</i>	?	60+?	?	0.1???	?	D?
Rig	<i>Mustelus</i>	5-8	20?	2	0.2-	0.11-	Ds

Common name	Scientific name	Age when mature	Maximum age	Age when first fished	M -natural mortality	Von B growth k	Risk rating
	<i>lenticulatus</i>				0.3	0.42	
Rock lobster	<i>Jasus edwardsii</i>	3-12	40+?	5-11	0.12	?	D?
Rubyfish	<i>Plagiogeneion rubiginosum</i>	7?	45-90+	7	0.03-0.1	0.045	F
Scampi	<i>Metanephrops challengeri</i>	3-4	15	3-4	0.2-0.25	0.11-0.14	D
School shark	<i>Galeorhinus galeus</i>	12-17	50+	10?	0.1	?	Ds
Sea perch	<i>Helicolenus percoides</i>	5-7	43	5	0.07-0.13	0.128-0.117	D?
Silver warehou	<i>Seriolella punctata</i>	3-4	23	3-4	0.2-0.3	0.33-0.41	B
Skates– rough	<i>Zearaja nasutus</i>	4-6	9+	?	0.25-0.35	0.096-0.16	Ds
Smooth	<i>Dipturus innominatus</i>	8-13	28+	?	0.12-0.15	0.095-0.117	Ds
Skipjack tuna	<i>Katsuwonus pelamis</i>	1	12?	1	0.3-2.0	0.52-1.30?	C?
Snapper	<i>Pagrus auratus</i>	3-4	60	3-5	0.051-0.075	0.061-0.16	D
Southern blue whiting	<i>Micromesistius australis</i>	2-4	25	3-4	0.2	0.032-0.035	D
Southern bluefin tuna	<i>Thunnus maccoyii</i>	8-12	30+	4	0.2?	0.14-0.18	D
Spiny dogfish	<i>Squalus acanthias</i>	6-10	26	4?	0.2	0.069-0.116	Ds
Sprats – Slender Stout	<i>Sprattus antipodum</i> <i>S muelleri</i>	? ?	? ?	? ?	? ?	? ?	A? A?
Stargazer	<i>Kathetostoma giganteum</i>	5-7	26	2-3	0.18-0.2	0.14-0.20	C
Stripped marlin	<i>Tetrapturus audax</i>	1-2?	12+?	2?	0.389-0.818	0.22?	C
Swordfish	<i>Xiphias gladius</i>	9-10	20?	?	?	0.22?	C
Tarakihi	<i>Nemadactylus macropterus</i>	4-6	40+	3-4	0.08-0.15	.1666-0.252	C
Trevally	<i>Pseudocaranx dentex</i>	3-5	40+	3-4	0.087	0.28-0.29	D
Trumpeter	<i>Latris lineatae</i>	?	?	?	?	?	C?
White warehou	<i>Seriolella caerulea</i>	3-4	23?	3-4	0.24-0.27?	?	C
Yellow-eyed mullet	<i>Aldrichetta forsteri</i>	2	7	2	0.66	?	A?
Yellow fin tuna	<i>Thunnus albacares</i>	2	8+	2	0.1-0.2 0.6-0.8?	0.250-0.660	C

References: Sullivan *et al* (comp) 2005, Annala J H, Sullivan K J, and O'Brien C J (comp) 2002 and 2003, Paul 1992, Neil *et al* 2004, Ministry of Fisheries 2008, Ministry of Fisheries 2009, Fishbase.org.

Appendix III

Marine Species Listed by the Bonn Convention, ACAP and CITES

1. Agreement on the Conservation of Albatross and Petrels (ACAP)

Table 1: Albatross, petrel and shearwater species listed in Annex 1 of ACAP

Bonn Convention Appendices I & II	New taxonomy*	
Albatrosses		
<i>Diomedea exulans</i> (II)	<i>Diomedea exulans</i>	Wandering
(Wandering)	<i>Diomedea dabbenena</i>	Tristan
	<i>Diomedea antipodensis</i>	Antipodean
<i>Diomedea amsterdamensis</i> (I)	<i>Diomedea amsterdamensis</i>	Amsterdams
<i>Diomedea epomophora</i> (II)	<i>Diomedea epomophora</i>	Sthn Royal
(Royal)	<i>Diomedea sanfordi</i>	Nthn Royal
<i>Diomedea irrorata</i> (II)	<i>Phoebastria irrorata</i>	Waved
<i>Diomedea cauta</i> (II)	<i>Thalassarche cauta</i>	Shy
(shy)	<i>Thalassarche steadi</i>	White-capped
	<i>Thalassarche salvini</i>	Salvin's)
	<i>Thalassarche eremite</i>	Chathams
<i>Diomedea bulleri</i> (II)	<i>Thalassarche bulleri</i>	Buller's
<i>Diomedea chrysostoma</i> (II)	<i>Thalassarche chrysostoma</i>	Grey-headed
<i>Diomedea melanophris</i> (II)	<i>Thalassarche melanophris</i>	Black-browed
	<i>Thalassarche impavida</i>	Campbell
<i>Diomedea chlororhynchos</i> (II)	<i>Thalassarche carteri</i>	Indian Yellow-nosed
	<i>Thalassarche chlororhynchos</i>	Atlantic yellow-nosed
<i>Phoebetria fusca</i> (II)	<i>Phoebetria fusca</i>	Sooty
<i>Phoebetria palpebrata</i> (II)	<i>Phoebetria palpebrata</i>	Light-mantled sooty
	<i>Phoebastria nigripes</i>	Black-footed Albatross
	<i>Phoebastria immutabilis</i>	Laysan albatross
	<i>Phoebastria albatrus</i>	Short-tailed albatross
Petrels		
<i>Macronectes giganteus</i> (II)	<i>Macronectes giganteus</i>	Sthn giant
<i>Macronectes halli</i> (II)	<i>Macronectes halli</i>	Nthn giant
<i>Procellaria aequinoctialis</i> (II)	<i>Procellaria aequinoctialis</i>	White-chinned
<i>Procellaria aequinoctialis conspicillata</i> (II)	<i>Procellaria conspicillata</i>	Spectacled
<i>Procellaria parkinsoni</i> (II)	<i>Procellaria parkinsoni</i>	Parkinson or Black
<i>Procellaria westlandica</i> (II)	<i>Procellaria westlandica</i>	Westland
<i>Procellaria cinerea</i> (II)	<i>Procellaria cinerea</i>	Grey

Notes:

1. Species in **bold** breed in New Zealand
2. * *New taxonomy follows:* Robertson, C.J.R. and Nunn, G.B. 1997. Toward a new taxonomy for albatrosses. Pp. 413-19 in Albatross biology and conservation, ed. by G. Robertson and R. Gales. Surrey Beatty & Sons, Chipping Norton; as modified by Croxall, J.P. and Gales, R. 1997. An assessment of the conservation status of albatrosses. Pp. 46-65 in Albatross biology and conservation, ed. by G. Robertson and R. Gales. Surrey Beatty & Sons, Chipping Norton; and Ryan, P.G. 1998. The taxonomic and conservation status of the spectacled petrel *Procellaria conspicillata*. Bird Conservation International 8: 223-235.

2. Other Relevant Marine Species covered by Bonn Convention:

Appendix I (endangered migratory species)

Species	Common name
<i>Physeter macrocephalus</i>	Sperm whale
<i>Balaenoptera borealis</i>	Sei whale
<i>Balaenoptera physalus</i>	Fin whale
<i>Balaenoptera musculus</i>	Blue whale
<i>Megaptera novaeangliae</i>	Humpback whale
<i>Eubalaena australis</i>	Southern right whale
<i>Chelonia mydas</i>	Green sea turtle
<i>Caretta caretta</i>	Loggerhead sea turtle
<i>Eretmochelys imbricate</i>	Hawksbill turtle
<i>Lepidochelys olivacea</i>	Olive Ridley turtle
<i>Dermochelys coriacea</i>	Leatherback, leathery turtle or Luth
<i>Carcharodon carcharias</i>	Great white shark
<i>Cetorhinus maximus</i>	Basking shark

Appendix II (migratory species covered through agreements)

Species	Common name
<i>Balaenoptera bonaerensis</i>	Antarctic minke whale
<i>Balaenoptera edni</i>	Bryde's whale
<i>Capera marginata</i>	Pygmy right whale
<i>Orcinus orca</i>	Orca
<i>Physeter macrocephalus</i>	Sperm whale
<i>Phocoena dioptrica</i>	Spectacled porpoise
<i>Lagenorhynchus obscurus</i>	Dusky dolphin
<i>Isus oxyrinchus</i>	Shortfin mako shark
<i>Isus paucus</i>	Longfin mako shark
<i>Lamna nasus</i>	Porbeagle shark
<i>Rhincodon typus</i>	Whale shark
<i>Squalus acanthias</i>	Spiny dogfish*

Note:

Species in bold are reported caught in New Zealand fisheries.

* Listed in northern hemisphere only.

3. Marine species listed by CITES

Interpretation

1. Species included in these Appendices are referred to:
 - a. by the name of the species; or
 - b. as being all of the species included in a higher taxon or designated part thereof.
2. The abbreviation "spp." is used to denote all species of a higher taxon.
3. Other references to taxa higher than species are for the purposes of information or classification only. The common names included after the scientific names of families are for reference only. They are intended to indicate the species within the family concerned that are included in the Appendices. In most cases this is not all of the species within the family.
4. The names of the countries in parentheses placed against the names of species in Appendix III are those of the Parties submitting these species for inclusion in this Appendix.

CITES Appendices (valid from 16 October 2003)		
I	II	III
FAUNA (ANIMALS)		
PHYLUM CHORDATA		
CLASS MAMMALIA (MAMMALS)		
CETACEA Dolphins, porpoises, whales		
Most whales (including beaked whales) and some dolphins	CETACEA spp. (Except the species included in Appendix I.)	
Otariidae Fur seals, sealions		
	Arctocephalus spp. (incl NZ fur seal)	
Phocidae Seals		
	Mirounga leonina (Sth Elephant seal)	
CLASS REPTILIA (REPTILES)		
Cheloniidae Marine turtles		
	Cheloniidae spp.	
Dermochelyidae Leatherback turtle		
	Dermochelys coriacea	
CLASS ELASMOBRANCHII (SHARKS)		
Rhincodontidae Whale shark		
	Rhincodon typus	
Lamnidae Great white shark		
	Carcharodon carcharias	
Cetorhinidae Basking shark		
	Cetorhinus maximus	
CLASS ACTINOPTERYGII (FISH)		
Syngnathidae Pipefishes, seahorses		
	Hippocampus spp.	
PHYLUM CNIDARIA		
CLASS ANTHOZOA		
(CORALS, SEA ANEMONES)		
ANTIPATHARIA Black corals		
	ANTIPATHARIA spp.	
SCLERACTINIA Stony corals		
	SCLERACTINIA spp. (Fossils are not subject to the provisions of the Convention)	

CLASS HYDROZOA (SEA FERNS, FIRE CORALS, STINGING MEDUSAE)	
STYLAsteridae Lace corals	
	STYLAsteridae spp. (Fossils are not subject to the provisions of the Convention)

Note: Listed tropical shells and cucumber species are not included in this Appendix.

Appendix IV

Bird Species Reported Caught in Quota Areas

Taxa	Tuna Longline	Ling Longline	Trawl (incl squid, hoki, scampi, jack mackerel, barracouta, oreo, orange roughy, warehou)	Other (incl snapper longline, inshore trawl, and set nets)
Albatross				
FMA 1	Campbell (v), Buller's (v), Gibson's (v), Salvin's (v)			
FMA 2	Antipodean (v), black-browed (e), Campbell (v), Chatham (cr), Gibson's (v), northern royal (e), Salvin's (v), white- capped (nt), wanderer	Wandering (e)	Pacific (v), Salvin's (v), white-capped (nt)	
FMA 3	Antipodean (v), Buller's (v), Gibson's (v), light- mantled sooty (nt), northern royal (e), white-capped (nt), wanderer	Salvin's (v)	Antipodean (v), Buller's (v), Salvin's (v), southern royal (v), white-capped (nt)	
FMA 4		Buller's (vu), Chatham (cr), Pacific (vu), Salvin's (v), white capped, Sthn Royal	Black-browed (e), Buller's (v), Campbell (v), Salvin's (v), white- capped (nt), Gibson's (v), Chatham's (e) Salvin's (v)	
FMA 5	Buller's (v), Campbell (v), Gibson's (v), light- mantled (nt), southern royal (v), white-capped (nt)	White capped	Buller's (v), Campbell (v), Salvin's (v), southern royal (v), white-capped (nt), Gibson's Chatham's Salvin's	
FMA 6		Salvin's (v)	Buller's (v), Campbell (v), white-capped (nt)	
FMA 7	Black-browed (e), Buller's (v), Campbell (v), Gibson's (v), light- mantled (nt), white- capped (nt)	White capped	Black-browed (e), Buller's (v), Campbell (v), white-capped (nt)	
FMA 10	Black-browed, wandering			
Petrel				
FMA 1	Black (v), flesh- footed shearwater		Flesh-footed shearwater (lc), sooty	Black (v), fleshfooted

	(lc), grey-faced, white-chinned, sooty shearwater		shearwater (nt), black petrel	shearwater (lc), grey-faced, buller's shearwater (v), fluttering shearwater (lc)
FMA 2	Northern giant (nt), black (v), grey (nt), white-chinned (v), flesh-footed shearwater, sooty shearwater	Sooty shearwater	Flesh-footed shearwater (lc), sooty shearwater (nt)	Grey (nt), shearwater, sooty shearwater (nt), cape (lc), Sthn giant
FMA 3	Grey (nt), white-chinned (v)	White-chinned (v), sooty shearwater	Grey (nt), sooty shearwater (nt), white-chinned (v), Northern giant (nt)	Yellow eyed penguins (e) Little shags Sooty shearwater (nt)
FMA 4		Southern cape, grey (nt), white-chinned (v), sooty shearwater	Northern giant (nt), grey-faced, grey (nt), white chinned (v), sooty shearwater (nt), Antarctic prion, southern cape	Cape pigeon, grey
FMA 5	Grey (nt), white-chinned (v), sooty shearwater	Common diving, sooty shearwater, white-chinned	White-chinned, black bellied storm, sooty shearwater, cape pigeon, grey-backed storm, black bellied storm	Cape pigeon, Nthn giant petrel, cape pigeon
FMA 6	White-chinned (v)	Northern giant (nt), southern giant (v), grey (nt), white-chinned (v), cape pigeon (lc), Snares cape and sthn cape.	Grey (nt), white-chinned (nt), black bellied storm (lc), sooty shearwater (nt), cape pigeon (lc), diving petrel, white-headed	
FMA 7			Cape pigeon, fairy prion, white-chinned, sooty shearwater, Nthn petrel, Sthn Cape pigeon	
FMA 8			Sooty shearwater	

Notes:

1. This is based on target species with captures of marine mammals observed by Ministry of Fisheries observers.
2. Information from Abraham and Thompson 2009, Baird (2001, 2004a, b, c, 2005a) and CSL Autopsy Reports including Robertson (2000), Robertson and Bell (2002a,b), Robertson *et al* (2003a,b) and Bartle (2000).
3. Threatened status of albatross according to IUCN 2003 – cr – critically endangered, e – endangered, v – vulnerable, nt – near threatened, lc – least concern.
4. FMA is the fisheries management area.
5. Bird bycatch may occur in other areas but there has been no or very low Ministry of Fisheries observer coverage.
6. There are also penguins and shags reported caught in inshore set net fisheries.

Appendix V

Marine Mammals Reported Caught in Quota Areas

	Sea lions (v)	Fur seals	Hector's (e) and Maui's dolphin (cr)	Other cetaceans (incl common dolphin and pilot whale)
FMA 1		Southern bluefin tuna longline		Southern bluefin tuna longline
FMA 2		Hoki/hake/ling trawl, southern bluefin tuna longline, bluenose longline and scampi trawl		Southern bluefin tuna longline
FMA 3		Hoki/hake/ling trawl, scampi trawl Squid trawl	Elephant fish/rig set net, Red cod/flatfish trawl	
FMA 4		Hoki trawl, Orange roughy trawl,		Ling longline
FMA 5	Squid trawl	Hoki trawl Jack mackerel trawl Barracouta trawl Tuna longline		Inshore trawl and Southern bluefin tuna longline
FMA 6	Squid Trawl Scampi trawl Southern blue whiting trawl Jack mackerel trawl Oreos trawl Orange roughy trawl Hoki trawl	Squid trawl Southern blue whiting trawl Hoki trawl Barracouta trawl Jack mackerel trawl Smooth oreo trawl Tuna longline Scampi trawl Ling longline		Ling longline
FMA 7		Hoki trawl Jack mackerel trawl Tuna longline Hake trawl Barracouta trawl Silver warehou trawl Frostfish trawl Ling trawl Southern bluefin tuna longline		Jack mackerel trawl Set net Southern bluefin tuna longline
FMA 8		Scampi trawl Hoki trawl		Jack mackerel trawl
FMA 9		Set Nets	Rig set net	Jack Mackerel trawl
FMA 10				

Note:

1. This is based on target species with captures of marine mammals observed by Ministry of Fisheries observers.
2. Other cetaceans caught include common, dusky dolphins and pilot whales.

3. Leopard seals and elephant seals are occasionally caught in sub-Antarctic (QMA6) including in the scampi trawl fishery.
4. For background information see Abraham and Thompson 2009, Baird 2001, 2004a, and 2005b, c, d,e, Manly *et al* 2002 a, b, c., and the CSL Autopsy Reports including Robertson and Bell (2000 and 2001) and Bartle (2000).
5. Threatened status of marine mammals according to IUCN 2003 – cr – critically endangered, e – endangered, v – vulnerable, nt – near threatened, lc – least concern.

Appendix VI

Turtle species reported caught

Turtle Species	Species	Fishery	Quota Areas
Leatherback turtle	<i>Dermochelys coriacea</i>	Swordfish and bigeye tuna	1, 10, 2, 5
Green turtle	<i>Chelonia mydas</i>	Snapper longline and tuna	9, 1
Unidentified turtles	?	Tuna fisheries	1, 2

Appendix VII

Highly Migratory Species and Straddling stocks

Name	Species	UNCLOS Appendix I	Convention	Highly Migratory or straddling stock
Albacore tuna	<i>Thunnus alalunga</i> .	Yes	WCPFC	HM
Pacific Bluefin tuna	<i>Thunnus orientalis</i>	Yes	WCPFC	HM
Bigeye tuna:	<i>Thunnus obesus</i>	Yes	WCPFC	HM
Skipjack tuna:	<i>Katsuwonus pelamis</i>	Yes	WCPFC	HM
Yellowfin tuna:	<i>Thunnus albacares</i>	Yes	WCPFC	HM
Southern bluefin tuna	<i>Thunnus maccoyii</i>	Yes	CCSBT	HM
Marlins	<i>Tetrapturus angustirostris</i> ; <i>Tetrapturus belone</i> ; <i>Tetrapturus pfluegeri</i> ; <i>Tetrapturus albidus</i> ; <i>Tetrapturus audax</i> ; <i>Tetrapturus georgei</i> ; <i>Makaira mazara</i> ; <i>Makaira indica</i> ; <i>Makaira nigricans</i> .	Yes	WCPFC	HM
Swordfish	<i>Xiphias gladius</i>	Yes	WCPFC	HM
Oceanic sharks	<i>Hexanchus griseus</i> ; <i>Cetorhinus maximus</i> ; Family <i>Alopiidae</i> ; <i>Rhincodon typus</i> ; Family <i>Carcharhinidae</i> ; Family <i>Sphyrnidae</i> ; Family <i>Isurida</i>	Yes	WCPFC	HM
Orange roughy	<i>Hoplostethus atlanticus</i>	No	-*	SS
Patagonian toothfish	<i>Dissostichus eleginoides</i>	No	CCAMLR	SS

Notes:

UNCLOS – United Nations Convention on the Law of the Sea

WCPFC – Western and Central Pacific Fisheries Commission

CCSBT – Commission on the Conservation of Southern Bluefin Tuna

CCAMLR – Commission on the Conservation of Antarctic Marine Living Resources

HM – High migratory species

SS – Straddling stock

* - South Pacific Regional Fisheries Management Organisation is currently being negotiated.

Appendix VIII

Acronyms and Glossary

A. Acronyms and Abbreviations

- ACAP** – Agreement on the Conservation of Albatrosses and Petrels.
- B₀** – The unfished, initial, or virgin recruited biomass for a stock.
- B_{MSY}** – The recruited biomass that supports the maximum sustainable yield.
- B_{MAY}** – The recruited biomass that will support the maximum average yield.
- B_{MCY}** – The recruited biomass that supports the maximum constant yield.
- CAY** - Current annual yield - this is the estimate of the maximum sustainable catch for the current year in reference to a level of fishing mortality which has an acceptable level of risk.
- CITES** – Convention on Trade in Endangered Species.
- CCAMLR** – Convention on the Conservation of Antarctic Marine Living Resources
- CCCSBT** – Convention on the Conservation of Southern Bluefin Tuna
- CMS** – Convention on Migratory Species.
- DoC** – Department of Conservation.
- ESY** – Ecologically sustainable yield – the yield an ecosystem can sustain without shifting to an undesirable state.
- F** – Fishing mortality rate is that part of the total mortality rate applying to the fish population that is caused by fishing.
- ITQ** - Individual Transferable Quota - quota share of the TACC. ITQs are property rights to a fishery granted in perpetuity which can be traded.
- M** - Natural mortality on a fishstock.
- MAY** - Maximum Average Yield - which is the long-term current annual yield and equivalent to MSY.
- MCY** - Maximum constant yield - the maximum constant catch that is sustainable with acceptable levels of risk at probable levels of future biomass for a fishstock.
- MFish** – Ministry of Fisheries
- MEY** - Maximum Economic Yield - the greatest difference between the costs of inputs and the values of outputs (catch). This is the sustained catch that produces the maximum economic value this is usually at a catch below MSY.
- MSY** - Maximum sustainable yield, in relation to any stock, means the greatest yield that can be achieved over time while maintaining the stock's productive capacity, having regard to the population dynamics of the stock and any environmental factors that influence the stock: (section 2, Fisheries Act 1996).
- OSY** – Optimum sustainable yield is the yield which considers factors in addition to maximum sustainable yield, for instance, effects on other species in the ecosystem and of other human uses of the ecosystem.
- SPRFMO** – South Pacific Regional Fisheries Management Organisation
- TACC** - Total Allowable Commercial Catch - this is the TAC minus an allowance for customary Maori fisheries, recreational fisheries and other mortality on a stock caused by fishing. The TACC is established under section 20 of the Fisheries Act 1996.
- TAC** - Total Allowable Catch of any fishstock this includes the TACC plus an allowance for non-commercial catches including customary Maori catch and other mortality caused by fishing. The TAC is established under section 13 or 14 of the Fisheries Act 96.
- Von B k** – This is the Brody growth co-efficient and defines the growth rate toward the maximum. This is from the standard Von Bertalanffy model (1938) which describes the growth in fish length. $L_t = l_\infty [1 - e^{-k(t-t_0)}]$ where l_∞ is the maximum body size and t_0 is the shift in the growth curve to allow for nonzero body length at age zero.
- WCPFC** – Western and Central Pacific Fisheries Commission.

B. Glossary

Aquaculture - aquatic species, such as fish and shellfish, in salt, brackish, or freshwater. Farming implies private ownership and enhancement of production by stocking, feeding, providing protection from predators and other management measures.

Beach-seine - A large enclosing net, brought out by boats and dragged to the (sandy) shore. Also a net used to encircle fish in shallow water; usually operated by two people wading out from shore, the net has lead weights to keep the bottom on the sea floor and floats to keep the top of the net at or near the surface. The seine may be set from a boat but hauled in from the land.

Benthic species or benthos – animals or plants living on the bottom of the ocean or lake.

Biological diversity - means the variability among living organisms, including diversity within species, between species, and of ecosystems:

[Section 2 of the Fisheries Act 1996]

The Biodiversity Convention also defines this as:

"Biological diversity" means the variability among living organisms from all sources including, inter alia, terrestrial, marine and other aquatic ecosystems and the ecological complexes of which they are part; this includes diversity within species, between species and of ecosystems.'

Biomass - an aggregate weight, at a particular time, of fish (or other organisms) in a stock or in a fishery.

Bottom trawl net - a net designed to trawl along the seabed and catch fish found close to the bottom such as orange roughy and oreos.

Bottom pair-trawl - a net designed to trawl along the seabed and catch fish found close to the bottom but towed between two similar trawlers.

Bycatch or bykill - those species killed in a fishery targeted on other species or a different size range of the same species and includes that part of the catch that has no commercial value and is discarded.

Catch - the total number or weight of fish and other marine life, including bycatch, taken by fishers from an area over some period of time, as opposed to landings, which do not reflect the amount of discards.

Commission for the Conservation of Antarctic Living Marine Resources - established by treaty in 1980, the CCAMLR is unique among fisheries agreements in that the conservation measures adopted by the Commission must include a fishery's impact on the entire ecosystem, rather than on just the targeted species. This ecosystem approach aims to prevent a decrease in the size of harvested populations to levels that threaten their stable recruitment, and to minimize the risk of changes in the marine ecosystem that are not potentially reversible over two or three decades. The meetings of the Commission are held annually in Hobart, Australia, with representatives of the 23 CCAMLR member states.

Continental shelf - The continental shelf is a gradually sloping undersea shelf of land that extends beyond shore of the continent. The nature of this geologic "shelf" is home to a great diversity of fish and shellfish species.

Copepods - a large group (approximately 6,000 species) of tiny shrimp-like crustaceans. They are an important food source for many larger animals, including fish, seabirds, and baleen whales.

Coral reefs - Coral reefs are built up over hundreds of years by colonies of small animals, called coral polyps, and their skeletons of calcium carbonate. Coral reefs cover less than 1% of the ocean area but are home to one-third of all marine fish species.

Crustacean - the aquatic equivalent of insects, also from the phylum Arthropoda. Found in both fresh and salt water, crustaceans are invertebrates and characteristically have a segmented body and exoskeleton, with limbs that are paired and jointed. Lobsters, crabs, shrimp and barnacles are examples of crustaceans.

Danish seine - A method of seining with a large net but the catch is landed on the vessel. Can be a single or two boat net where an area of water of about 2 square kilometres is swept as two encircling ropes leading to a trawl-like net are retrieved by the vessel(s). Fish within the ropes are herded into the net during hauling.

Demersal species - fish found on or near the bottom of the ocean, for example orange roughy.

Depleted fishery - a fishery where the population has been reduced to less than that which would support the maximum sustainable yield.

Developed fishery - a fishery operating at or near the level of the maximum sustainable yield, subject to other environmental constraints.

Developing fishery - a fishery in which experimental or feasibility fishing is being undertaken to determine whether the resource can support a viable fishery.

Dip-net - A net used for transferring the catch of a deep-sea seine after it has been brought alongside. It is operated either entirely by hand or partly by hand and partly by mechanical power. Other names are scoop, brailer, spoon net, brail net, and hand brailer.

Driftnet - A gillnet weighted at the bottom and supported by floats at the top which drifts with the tide or current. Large driftnets used to be in excess of 50 km on the high seas and in New Zealand EEZ can be no longer than 1km.

Dragnet - A small net pulled by two or more people which is dragged along the bottom.

EEZ - Exclusive Economic Zone - the zone from 12 nautical miles out to 200 nautical miles offshore established pursuant to international agreement under the United Nations Convention on the Law of the Sea.

Fishing effort - the amount of fishing activity undertaken. It is usually measured by the total time spent fishing combined with the quantity of gear used, for example the catch per thousand hooks or the catch per trawl. This provides the level of effort in CPUE. Nominal fishing effort provides an indirect measure of fishing mortality.

Fecundity - the level or rate of egg or offspring production. Fecundity may change with the size and age of a species.

Finning - the practice of cutting off the fins of sharks and discarding the carcasses overboard. Asia is the primary market for shark fins, which are used to make shark fin soup. Congress banned shark-finning in all U.S. waters in 2000.

Fishery - can be defined in many ways though, in general terms, it is the take or removal of a species from the aquatic environment using some type of fishing technology. The emphasis is on the human aspects of fishing and all the activities it involves.

Food chain - the sequence of organisms through which energy and materials are transferred (in the form of food), or the linear progression of feeding levels in which one organism is the food source for the next.

Food web - the complex, interlocking series of individual food chains in an ecosystem, i.e., all the predator-prey relationships.

Fyke net - A long bag net distended by hoops, into which fish can pass easily, without being able to return.

Globally threatened species - a species that is globally threatened with biological extinction under the World Conservation Union criteria, which are Critically Endangered, Endangered and Vulnerable.

Growth over-fishing - this is when the losses due to natural and fishing mortality exceeds the gains due to recruitment and growth during the same period. This is usually reflected by a reduction in the size of the fish being harvested.

High-grading - the practice of discarding at sea all or a portion of a vessel's legal catch in order to obtain a higher or larger grade of fish that brings higher prices. It may occur in both quota and nonquota fisheries. (Roberts *et al.*)

Hinaki - traditional Maori woven eel net traps made from supplejack and flax.

Invertebrate - jellyfish, octopus and sponge are examples of marine invertebrates, or animals without a backbone. In fishery management terms, invertebrate usually refers to shellfish, such as lobsters, shrimp, oysters and scallops.

Jig - a multi-barbed hook used mainly to catch squid.

Lampara net - Similar to, but much smaller than, a purse seine with no pursing action. This net is generally used for catching artificial light attracted schools of small fish such as anchovy and pilchard. There is a central spoon-shaped section and two lateral wings and the net is usually operated from a small boat. The rapid retrieval of the lead line does close the bottom of the net but it is not a true purse.

Landings - commercial landings are defined as the quantity of fish and shellfish brought ashore for sale. The term also applies to the amount caught for personal use by recreational fishermen. This measurement does not include the amount of bycatch incidentally caught and discarded dead at sea.

Maximum sustainable yield - the maximum amount of a species that can be taken without diminishing the future take.

Metric tonne - often the unit of measurement for commercial and recreational landings, a metric tonne is equal to 1000 kilograms, 0.984 long tons, 1.1023 short tons, or 2204.6 pounds.

Mid-water trawl - a trawl designed catch species in mid-water eg hoki and southern blue whiting. These trawl nets can have 60 metre headline heights (top to bottom on net) and opening over 150m wide.

Nautical mile - one nautical mile is the equivalent of 1.15 statute miles.

Overcapitalization - this occurs when there is more fishing capacity (ie, more boats, gear or investment in equipment) than is needed to catch the available amount of fish in an economically efficient and sustainable manner. Overcapitalization poses a threat to fish populations because it can easily lead to over-fishing.

Over-fishing - over-fishing exists when the rate of fishing is greater than the level required to meet the management goal or maximum sustainable yield. In other words, over-fishing occurs when a population of fish is caught faster than it can replenish itself through reproduction. (Roberts *et al.*)

Pelagic - an ancient Greek word for the open ocean or high seas, the area comprising most of the Earth's surface.

Pelagic species - species found near the surface of the sea and not on or near the seabed, for example tuna and kahawai.

Plankton - small plant and animal species that spend at least part of their time on the sea surface. They rely in large part on ocean currents for distribution and transportation. As eggs and larvae, many marine species, such as cod and Dungeness crabs, are planktonic for part of their life cycle. The plankton provide food for many commercially important fish and form the basis of ocean food webs. Some of the largest marine creatures, such as whale sharks and blue whales, eat plankton. Zooplankton are animals and phytoplankton are plants.

Population - a group of interbreeding organisms that represents the level of organization at which speciation begins. In other words, a population is a group within a species that shares common ecological and genetic features compared to other individuals of that species.

Precautionary principle - a proactive method of dealing with the environment that places the burden of proof on those whose activities could harm the environment rather than on the public. It is the opposite of the wait-and-see principle; acting before scientific proof of deleterious effects is applying a precautionary approach. (Norse)

Purse seine - a floating net designed to surround fish and can be closed at the bottom, or "pursed" by means of a free-running line attached to the bottom of the net. The net may be of up to 1 km length and 300 m depth and is used to encircle surface schooling fish such as kahawai, trevally and skipjack tuna. During retrieval the bottom of the net is closed or pursed by drawing a purse line through a series of rings to prevent the fish escaping.

Recruit - a fish entering the period in its life history when it is exposed to fishing. Related phrases include pre-recruits, age or length at recruitment, recruitment failure.

Recruitment - recruitment is the general replacement of fish to a stock or population. In fisheries it is the time when a fish grow to a size they become liable to be caught in fishing gear.

Recruitment failure - the failure of the fishstock to be replaced by recruits.

Recruitment over-fishing - occurs when the spawning stock has been reduced to a level at which recruitment of young fish entering the exploited component of the fishery is significantly reduced.

Ring net - A modified lampara net with purse rings operated by two vessels.

Seamount - underwater volcanic mountain, ridges and plateaus that rise up several kilometres from the sea floor, but do not reach the surface of the sea.

Seine - a type of fishing net that encircles a school of fish.

Set - to prepare and cast a net; one "set" is typically defined as the interval from the time the net is cast to the time the net is hauled in.

Set net - a type of gill net that has been intentionally set, staked or anchored or otherwise fixed in stationary position, as opposed to drift nets.

Stock - the technical definition of a stock is an interbreeding sub-population of a species, reproductively isolated to some extent from other populations. Used as a unit for fishery management, however, "stock" refers to a specific population or group of populations of one or more species.

Territorial Sea - this is sea within 12 nautical miles from low-water line along the coast.

Trammel net - type of gill net with three panels suspended from a common surface line and attached to a single bottom line. The two outside panels are of a larger mesh than the inside panel.

Trawl - net with a wide mouth tapering to a small, pointed end, usually called the cod end. Trawls are towed behind a vessel at any depth in the water column.

Trolls - lines with lures or baited hooks that are drawn through the water from a vessel while in motion.

Appendix IX

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Appendix X

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