



Ministry of
Fisheries
Te Tautiaki i nga tini a Tangaroa

New Zealand Government

Harvest Strategy Standard for New Zealand Fisheries

Ministry of Fisheries — October 2008



■ Foreword

New Zealand's fisheries are of great value to us all. They contribute to our nation's economy, provide recreational and customary fishing opportunities to many New Zealanders, and are of considerable social, cultural and environmental significance.

I am pleased to introduce the Harvest Strategy Standard, which I believe will make a significant contribution to managing New Zealand's fisheries into the future. The Harvest Strategy Standard provides for targets and limits to be set for our fisheries and fish stocks. It will be used to guide development of fisheries plans, help us make better decisions about catch limits, and help us achieve our objective of providing for the use of New Zealand fish stocks while ensuring their sustainability.

There is no universally-recognised best method for setting fisheries targets and limits. When developing the Harvest Strategy Standard, best-practice approaches of other countries and international fisheries organisations were considered and adapted to suit New Zealand's unique management system. Adopting a best practice approach helps ensure New Zealand's fisheries management keeps its place at the forefront of fisheries management internationally.

Use of a best-practice Harvest Strategy Standard will support New Zealand's efforts to gain environmental certification for its fisheries. It will also provide the fishing industry and other stakeholders with a more certain and consistent operating environment. The Harvest Strategy Standard will further enhance our ability to make sound fisheries management decisions for the benefit of all New Zealanders and the health of the aquatic environment.



Hon Jim Anderton
Minister of Fisheries

24 October 2008

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■ Introduction

1. The Ministry of Fisheries (“the Ministry”) is developing a comprehensive fisheries management regime designed to provide sustainable fisheries now and in the future. Fisheries standards are a key component of that management regime. A standard represents the minimum performance level determined by Government to be acceptable. This determination will be based on international best practice.
2. The Harvest Strategy Standard is a policy statement of best practice in relation to the setting of fishery and stock targets and limits for fishstocks in New Zealand’s Quota Management System (QMS). It is intended to provide guidance as to how fisheries law will be applied in practice, by establishing a consistent and transparent framework for decision-making to achieve the objective of providing for utilisation of New Zealand’s QMS species while ensuring sustainability. The Harvest Strategy Standard outlines the Ministry’s approach to relevant sections of the Fisheries Act 1996 (“the Act”), and, as such, will form a core input to the Ministry’s advice to the Minister of Fisheries (“the Minister”) on the management of fisheries, particularly the setting of TACs under sections 13 and 14.
3. The metrics specified in the Harvest Strategy Standard are to be treated as defaults: i.e. they should be applied in most situations. Where proposed management options depart from the Harvest Strategy Standard, they must be justified in terms of the particular circumstances that warrant such departure.
4. The Harvest Strategy Standard needs to be interpreted by reference to the Glossary of Terms (Appendix I) and the footnotes, both of which provide explanation and elaboration of the statements made in the text, and are integral parts of the Harvest Strategy Standard. It is also essential to refer to the companion document entitled “Operational Guidelines for New Zealand’s Harvest Strategy Standard”, which incorporates both technical and implementation guidelines. The sections on technical guidelines provide suggested methods for calculating or approximating the biological reference points specified in the Harvest Strategy Standard, a more detailed basis and justification for the metrics specified in the Harvest Strategy Standard, and elaboration on how the Harvest Strategy Standard should be implemented. The sections on implementation guidelines specify the respective roles and responsibilities of fisheries managers, scientists and stakeholders in giving effect to the Harvest Strategy Standard.
5. The Harvest Strategy Standard itself specifies only a small number of standards *per se*, with most of the technical, interpretation and implementation aspects set out in the Operational Guidelines. It is intended that the core standards will not change substantively in the short term, but should be subject to review in a period not exceeding five years, based on the evolution of fisheries plans and fisheries management strategies in New Zealand, and the evolution of international best practice. However, the Operational Guidelines will continually evolve as new data, analyses and insights become available.

6. In recognition of the differences in the nature and purpose of the Harvest Strategy Standard and the associated Operational Guidelines, the Harvest Strategy Standard has been approved by the Minister of Fisheries, while the Operational Guidelines will be periodically revised and approved by the Ministry's Chief Executive based on advice from the Chief Scientist and the National Manager Fisheries Operations. The Chief Scientist will develop revisions to the technical sections of the Operational Guidelines in collaboration with stakeholders in periodic meetings of the Stock Assessment Methods Working Group.

What is a harvest strategy?

7. Internationally, there are two alternative uses of the term "harvest strategy". The simplest one is that the harvest strategy specifies target and limit reference points and management actions associated with achieving the targets and avoiding the limits. This is sometimes referred to as a "harvest control rule". The more comprehensive definition takes a systems approach that links together a stock assessment process and management and monitoring controls, along with associated performance measures, and sometimes also includes research and enforcement needs. For the purposes of the Harvest Strategy Standard, the definition adopted is the simpler one, with the more comprehensive definition being referred to as a "management strategy". The process of evaluating alternative management strategies against one or more operating models (simulation models of the real world) is termed a "management strategy evaluation" (MSE).

■ Scope

8. The Harvest Strategy Standard is a key input to the setting of TACs under the Fisheries Act. It provides guidance in relation to the specifications for setting TACs stated in sections 13, 14, 14A and 14B of the Act, but must also be read in conjunction with other relevant sections of the Act. The relationship of the Harvest Strategy Standard to these and related provisions of the Act is outlined in Appendix II.

9. However, the Harvest Strategy Standard is not the only input into the setting of TACs. The Harvest Strategy Standard is concerned with the application of best practice in relation to the setting of fishery and stock targets and limits, but it is focussed on single species biological considerations and related uncertainties, and includes only limited consideration of economic, social, cultural or ecosystem issues. Although it will form a core basis for the Ministry's advice to the Minister, other considerations such as environmental principles (section 9) and economic, social, and cultural factors also play a role in the advice to, and decisions by, the Minister.

10. Other standards that will subsequently be developed may result in modifications to the Harvest Strategy Standard to incorporate environmental and other considerations.

■ Conformance with the 2008 Amendments to the Fisheries Act 1996

11. During the course of development of the Harvest Strategy Standard, an amendment to the Act of direct relevance to the Harvest Strategy Standard was enacted.

12. In February 2008, section 13(2) of the Act was determined by the High Court to require estimates of both the current biomass and the biomass required to produce the maximum sustainable yield in order to be operable. This effectively negated the use of alternative approaches to meeting the requirement to maintain stocks at or above the biomass associated with maximum sustainable yield that had been developed and applied since the inception of the QMS in 1986.

13. The Act was subsequently amended to encompass other viable approaches, primarily by adding sub-section 13(2A), which states that “if the Minister considers that the current level of the stock or the level of the stock that can produce the maximum sustainable yield is not able to be estimated reliably using best available information, the Minister must ... (c) set a total allowable catch ... (ii) that is not inconsistent with the objective of maintaining the stock at or above, or moving the stock towards or above, a level that can produce the maximum sustainable yield”.

14. The phrase, “not inconsistent with the objective of maintaining the stock at or above, or moving the stock towards or above, a level that can produce the maximum sustainable yield” is understood to encompass compatible maximum sustainable yield (MSY) concepts that are likely to achieve the stated objective. The combination of sub-sections 13(2) and 13(2A) allows a number of viable approaches to defining or approximating MSY concepts; these have been incorporated into the Harvest Strategy Standard and the Operational Guidelines.

■ Concepts and Nomenclature

15. For the sake of brevity, most terms used in the Harvest Strategy Standard are defined in the Glossary (Appendix I) or the footnotes, or both, rather than in the main text. However, two concepts that are key to the Harvest Strategy Standard require elaboration up front. The two concepts are “MSY-compatible reference points” and “fishery or stock targets”.

16. In order to encompass all viable approaches covered by sub-sections 13(2) and 13(2A) of the Act, the Harvest Strategy Standard uses the short-hand phrase “MSY-compatible reference points or better”. MSY-compatible reference points include those related to stock biomass (i.e. B_{MSY}), fishing mortality ¹ (i.e. F_{MSY}) and catch (i.e. MSY itself), as well as analytical and conceptual proxies (i.e. approximations) for each of these three quantities. Guidance on methods for calculating the reference points (including their proxies) is contained in the Operational Guidelines. “Or better” means being above B_{MSY} or its proxies, and/or below F_{MSY} or its proxies, and/or below MSY or its proxies.

17. A minimum requirement for satisfying the Harvest Strategy Standard is that “fishery or stock” targets will be set at the level of MSY-compatible reference points; however, they may also exceed this minimum requirement (which is what is meant by “or better”).

18. In general, scientific working groups will estimate MSY-compatible reference points, and management working groups will set fishery or stock targets that consider these estimates as an input, along with other relevant factors. The respective roles and responsibilities of managers, scientists and stakeholders are outlined in more detail in the sections on implementation guidelines in the Operational Guidelines.

¹ Throughout this document, the term “fishing mortality” or “fishing mortality rate” can be readily substituted with the term “exploitation rate”.

■ Rationale

19. The essential requirements of section 13 are to maintain stocks at or above a level that can produce the maximum sustainable yield and to rebuild stocks that are below this level, consistent with the purpose of the Act of providing for utilisation while ensuring sustainability (section 8). Important issues addressed by the Harvest Strategy Standard include:

- Recognising and encompassing all MSY-compatible reference points. Sub-sections 13(2) and 13(2A) enable a variety of MSY-compatible reference points to be applied for different stocks by fisheries managers and scientists, depending on the type and amount of data available, the characteristics of the fisheries upon them, and international best practice. The Harvest Strategy Standard aims to formalise and standardise these alternative approaches while still retaining adequate flexibility to address the unique aspects of each fishery, and ensuring that statutory tests are applied in accordance with fisheries law.
- Providing a scientific and technical basis for rebuilding stocks. Some stocks are depleted below targets based on MSY-compatible reference points and, without a sound scientific and technical basis for decision-making, management interventions to rebuild them back to these targets may not be sufficient to achieve the desired level of rebuild in a timely manner.
- Providing the ability to specify biomass limits below which formal, time-constrained rebuilding plans should be implemented (herein called soft limits) and/or formal biomass limits below which closure of fisheries should be considered (herein called hard limits), both of which constitute current or emerging international best practice.

20. Defensible, clear and unambiguous standards to address the above issues are also necessary in the context of the current international trend towards eco-certification of fish products.

21. Sections 14 and 14B of the Act provide less guidance than section 13 on how TACs should be set. The Harvest Strategy Standard also clarifies the scientific and technical basis on which decisions should be made under these sections.

■ Core Elements of the Harvest Strategy Standard

Objective

22. The objective of the Harvest Strategy Standard is to provide a consistent and transparent framework for setting fishery and stock targets and limits and associated fisheries management measures, so that there is a high probability of achieving targets, a very low probability of breaching limits, and acceptable probabilities of rebuilding stocks that nevertheless become depleted, in a timely manner. The Harvest Strategy Standard specifies appropriate probabilities that will achieve each of these outcomes.

Specifications

23. The Harvest Strategy Standard consists of three core elements:

- > A specified target about which a fishery or stock should fluctuate;
- > A soft limit that triggers a requirement for a formal, time-constrained rebuilding plan; and
- > A hard limit below which fisheries should be considered for closure.

24. Each of these is elaborated below.

A specified target about which a fishery or stock should fluctuate

- > All fisheries managed under sections 13 and 14 (excluding those managed under section 14B) of the Act should be managed to fluctuate around a specified target.
- > For all section 13 stocks and most section 14 species (excluding stocks or species listed under section 14B), fisheries should be managed to fluctuate around a target based on MSY-compatible reference points or better ² with at least a 50% probability of achieving the target.

Stock productivity considerations

- > Estimates of, or adoption of, MSY-compatible reference points ² must take account of the productivity of the stock in question.
- > Such estimates will generally be inversely correlated with stock productivity; i.e. high productivity stocks are likely to have relatively lower estimates of B_{MSY} and vice versa.³

A soft limit that triggers a requirement for a formal, time-constrained rebuilding plan

- > The default soft limit is $\frac{1}{2} B_{MSY}$ or 20% B_0 , whichever is higher. ^{4, 5, 6}

² Refer to paragraphs 16-17 for the definition of the phrase, "MSY-compatible reference points or better".

³ Guidance on means of incorporating productivity considerations into estimates of MSY-compatible reference points is given in the Operational Guidelines.

- > The soft limit will be considered to have been breached when the probability that stock biomass is below the soft limit is greater than 50%.
- > Stocks that have fallen below the soft limit should be rebuilt back to at least the target level in a time frame between T_{min} and $2 * T_{min}$ ⁷ with an acceptable probability.
- > Stocks will be considered to have been fully rebuilt when it can be demonstrated that there is at least a 70% probability that the target has been achieved⁸ and there is at least a 50% probability that the stock is above the soft limit.
- > The default levels at which the soft limit is set should generally be considered as a minimum standard, with higher soft limits being used for some stocks, particularly those with low productivity. However, there are also circumstances where lower levels could be considered.⁹
- > Use of a “soft” limit as a biological reference point that triggers a requirement for a formal, time-constrained rebuilding plan does not imply that no action needs to be taken to rebuild stocks that have fallen below targets but have not yet declined to the level of the soft limit. Management action needs to be continually applied to ensure that fisheries and stocks fluctuate around target levels, particularly when they start to fall below those targets.¹⁰ Such management action is likely to involve reductions in fishing mortality rates and TACs, and/or implementation or modification of input

⁴ Similar fractions or percentages of other MSY-compatible reference points (including proxies)² are acceptable. Guidance on choosing these reference points will be developed periodically and added to the Operational Guidelines.

⁵ The use of $\frac{1}{2} B_{MSY}$ as a limit that triggers the need for a formal, time-constrained rebuilding plan has been adopted for many fisheries in the United States for up to a decade based on advice from Restrepo *et al.* (1998), and has subsequently been adopted or considered by an increasing number of other national and international organisations.

⁶ The implicit “equivalence” between $\frac{1}{2} B_{MSY}$ and 20% B_0 could be taken to mean that B_{MSY} itself should be of the order of 40% B_0 . This is in fact the default adopted by several national or regional fisheries management organisations which have similar legislative or policy obligations (e.g. the U.S. North Pacific Fisheries Management Council, the U.S. Pacific Fisheries Management Council and the Australian Commonwealth). The recent fisheries science and fisheries management literature indicates that levels of this order are applicable for fish stocks with “average” productivity (refer to the Operational Guidelines). 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).

⁷ T_{min} is the theoretical number of years required to rebuild a stock to the target in the absence of fishing. It is a function of three primary factors: the biology of the species, the extent of stock depletion below the target, and prevailing environmental conditions.

⁸ Use of a probability level greater than 50% ensures that rebuilding plans are not abandoned too soon; in addition, for a stock that has been depleted below the soft limit, there is a need to rebuild the age structure as well as the biomass, and this may not be achieved by using a probability as low as 50%.

⁹ For example, this may be reasonable for stocks with large natural fluctuations (or, equivalently, high natural mortality) that might be expected to fluctuate below the default soft limit more than 10% of the time even when managed so as to fluctuate around a target based on MSY-compatible reference points or better.² However, rigorous scientific evaluations will need to be undertaken to justify lower soft limits.

controls such as gear restrictions and seasonal or area closures. The role of the soft limit is to ensure that subsequent management action is sufficiently strengthened if previous action has not been adequate to prevent the stock declining to or below the soft limit.

- > To the extent possible, rebuilding plans should ensure that stocks do not decline below the biomass levels that triggered the need for a rebuilding plan.
- > The soft limit, and the associated need for management action, establishes a buffer to ensure that stocks do not breach the hard limit, which may result in fisheries closures.

A hard limit below which fisheries should be considered for closure

- > The default hard limit is $1/4 B_{MSY}$ or $10\% B_0$, whichever is higher.^{4, 11}
- > The hard limit will be considered to have been breached when the probability that stock biomass is below the hard limit is greater than 50%.
- > The default level at which the hard limit is set represents a minimum standard; higher hard limits may be appropriate for some stocks, particularly those with low productivity.
- > The hard limit is the biological reference point at which closure should be considered for target fisheries; it may be also be appropriate to consider curtailment or closure of fisheries that incidentally catch the species concerned.
- > Fisheries that have been closed as a result of breaching the hard limit will not be re-opened until it can be demonstrated that there is at least a 70% probability that the stock has rebuilt to or above the level of the soft limit.^{12,13}
- > Hard limits lower than the defaults should generally not be adopted.¹⁴

¹⁰ The Operational Guidelines provide guidance on how this can be achieved.

¹¹ A hard limit of $10\% B_0$ has been implemented in several fisheries worldwide. For example, the U.S. Pacific Fisheries Management Council routinely uses a "40:10 default harvest rule" whereby stocks are fished at a constant optimal rate provided they are above $40\% B_0$ and are closed once they fall below $10\% B_0$ (with fishing mortality decreasing linearly between these levels). Even more restrictive hard limits have also been implemented. For example, a hard limit of $20\% B_0$ has been adopted for Gulf of Alaska walleye pollock. Australia has also implemented a limit that may result in targeted fishing of key commercial species ceasing at biomass levels below $20\% B_0$ for some Commonwealth fisheries (Australian Fisheries Management Authority 2007).

¹² Use of a probability level greater than 50% ensures that closed fisheries are not re-opened too soon, as this could quickly lead to the need for reconsideration of closure.

¹³ In order to demonstrate that there is at least a 70% probability that the stock has rebuilt to or above the level of the soft limit it will probably be necessary to allow research fishing on closed fisheries.

¹⁴ There is widespread concern, and some evidence, that when stocks are reduced to low levels they may remain in a depressed state for many years due to depensation. FAO (2001) characterises depensation in the following way: "depensation is defined as a negative effect on population growth that becomes proportionately greater as population size declines. Populations experiencing depensation are prone to further reductions in size, even in the absence of exploitation, and therefore have a greater risk of extinction".

■ Application of the Harvest Strategy Standard in Management Strategy Evaluations

25. In recent years, Management Strategy Evaluations (MSEs) have gained international prominence as a fisheries management tool (see the appendices to the Operational Guidelines) and are currently in use in a small number of New Zealand fisheries with several more being planned. MSEs are fully-compatible with the Harvest Strategy Standard. The three core components of the Harvest Strategy Standard (a specified target based on MSY-compatible reference points or better,² a soft limit, and a hard limit, all with associated acceptable probabilities and management actions), simply provide minimum performance standards, or minimum performance measures, for MSEs and do not restrict alternative management objectives, or innovative management strategies, or additional performance measures beyond this.

26. MSEs should be designed to ensure that:

- > the probability of achieving the MSY-compatible target or better ² is at least 50%;
- > the probability of breaching the soft limit does not exceed 10%,¹⁵ and
- > the probability of breaching the hard limit does not exceed 2%.¹⁶

Amalgamating soft and hard limit metrics

27. A potential problem with requiring management strategies to incorporate a maximum acceptable probability of 2% for breaching the hard limit is that this may require large numbers of computations for evaluating alternative management strategies designed to meet the Harvest Strategy Standard. Therefore, for the purpose of the Harvest Strategy Standard, management strategies that collapse the requirements of “no more than a 10% probability of breaching the soft limit” and “no more than a 2% probability of breaching the hard limit” into a single requirement of “no more than a 5% probability of breaching the soft limit” will generally be acceptable.¹⁷

¹⁵ A maximum of a 10% probability of falling below 20% B_0 is consistent with what has been common practice for many assessed New Zealand stocks since 1992 (e.g. Francis 1992).

¹⁶ Francis and Mace (2005) demonstrated that probability levels even lower than 2% will not substantially reduce long-term average yields over and above those that would be achieved from harvest strategies designed to meet the default soft limit constraint, except in the case of constant catch strategies that are not responsive to reductions in stock size.

¹⁷ This combination constraint has been demonstrated to be more restrictive than the two constraints considered together for some stocks (e.g. CRA7 and CRA8).

■ Characterisation of Fishery and Stock Status

28. The status of fisheries and stocks will be characterised in the following way:

- > If the MSY-compatible fishing mortality rate, F_{MSY} , or an appropriate proxy is exceeded on average,¹⁸ **overfishing** will be deemed to have been occurring, because stocks fished at rates exceeding F_{MSY} will ultimately be depleted below B_{MSY} .
- > A stock that is determined to be below the soft limit will be designated as **depleted**¹⁹ and in need of rebuilding.
- > A stock that is determined to be below the hard limit will be designated as **collapsed**.

■ Information Considerations

29. In general, fishery and stock targets and limits should be set more conservatively for stocks with lower levels of information or higher levels of uncertainty, due to the higher risks associated with managing such fisheries on a long-term basis to provide for utilisation while ensuring sustainability. It must, however, be noted that the amount of data available for a fishery will not necessarily be well-correlated with the amount of useful information contained in those data and the associated stock assessment models. This will depend on the type of data available and the credibility and robustness of the assessment models.

¹⁸ A 3-5 year running average of the estimated fishing mortality rate or proxy will be deemed to be appropriate for evaluating whether or not “overfishing” has been occurring.

¹⁹ The term “depleted” is used in preference to “overfished” (which is the common categorisation for stocks near or below biomass limits in other parts of the world) because stocks can become depleted through a combination of overfishing and environmental factors, and it is usually impossible to separate the two.

■ Implications

30. Implementation of the Harvest Strategy Standard will bring about a number of changes to the current fisheries management regime in implementing targets, limits and rebuilding plans. However, there will be few, if any, implications of applying the Harvest Strategy Standard to New Zealand fisheries that have been managed to fluctuate around scientifically-defensible estimates of MSY-compatible reference points or better.

31. The Harvest Strategy Standard is consistent with international best practice. For stocks for which current estimates of MSY-compatible reference points or better are found to be inconsistent with international best practice, it may be necessary to develop new estimates, along with appropriate harvest strategies, to achieve the associated targets and avoid the associated limits.

32. Implementation of a best practice standard provides a basis for achieving certification of the New Zealand fisheries management framework and individual fisheries. Adoption and implementation of the Harvest Strategy Standard is expected to have positive benefits for New Zealand's initiatives to gain environmental certification for its fisheries.

33. The likely implications of implementing the Harvest Strategy Standard for specific fisheries will be detailed in the Operational Guidelines as case studies become available.

■ Application of the Harvest Strategy Standard to Specific Fishery Situations

New or developing fisheries

34. New or developing fisheries should be managed cautiously because there is generally little known about the size of the stock, or stock productivity, or stock status, during the development phase. The fishing mortality rate should not exceed F_{MSY} , and should probably be lower than this level.²⁰ Where F_{MSY} is unknown, it may be approximated by assuming equivalence between F_{MSY} and an estimate of natural mortality.²¹ Initial target catches should be set on the basis of the product of F_{MSY} (or appropriate proxies) and a conservative estimate of the average annual stock biomass (or appropriate proxies).

35. Explicit fishing-down phases that apply fishing mortality rates higher than F_{MSY} (or appropriate proxies) should generally be avoided, because these are unsustainable in the long term and usually result in a build-up of fishing capacity that often cannot easily be re-directed once the “fishing-down” phase is over. The combination of poor information, high fishing mortality rates, and overcapacity frequently results in targets being overshoot, particularly for low productivity species.²²

Established, well-managed fisheries

36. By definition, well-managed fisheries are those that fluctuate around appropriate targets and remain well above limits. Management action should ensure that this situation continues. The Operational Guidelines specify the types of management actions that should be used to ensure that fisheries fluctuate around appropriate targets, well above limits.

Fisheries on depleted stocks

37. Depleted stocks¹⁹ are defined as those that have been reduced below $\frac{1}{2} B_{MSY}$ or 20% B_0 , whichever is higher.^{4, 5, 6} Stocks may become depleted through overfishing, or unfavourable environmental conditions, or a combination of both. However, similar management actions to rebuild such stocks are required in each of these situations. Fisheries on depleted stocks should be curtailed to promote rebuilding, or considered for temporary closure, depending on their status relative to the soft and hard limits.

²⁰ This is also in line with the U.N. Fish Stocks Agreement of 1995, which views F_{MSY} as a minimum standard for limit reference points (Annex II of that document); however, the Harvest Strategy Standard sets F_{MSY} as a maximum target, rather than as a limit to be avoided.

²¹ There is considerable scientific literature dealing with the issue of whether equating F_{MSY} with natural mortality (M) is reasonable. The earlier literature (prior to the early 1990s) generally reported F_{MSY} values above M ; therefore setting F_{MSY} equal to M was considered to be conservative. Subsequently, the frequency of estimates of F_{MSY} below M and advice on setting target fishing mortality rates to be less than M has increased (e.g. Mace 1994, Walters and Parma 1995).

²² See FAO (2007), Sissenwine and Mace (2007) and various CCAMLR documents.

Fisheries managed on a rotational or enhanced basis

38. The terms “rotational” (fishing) and “enhanced” (stocks) have restricted meanings in a fisheries context. A rotationally managed fishery is one that has a planned cycle of selectively harvesting different areas occupied by a stock. An enhanced stock is one where individuals of a species are artificially grown and returned to wild stock, or areas are re-seeded through human intervention, so that the wild stock may be enhanced beyond a level that the stock can produce by natural processes alone.

39. To be effective, management on a rotational or enhanced basis must be compatible with the biological characteristics of the species concerned. Generally, rotational harvesting is only appropriate for short-lived, highly-productive sessile or semi-sessile species. The rationale for rotational harvesting is that by leaving certain areas (e.g. scallop or mussel beds) unfished for a few years, small individuals will be able to grow to a desirable size before being harvested, usually resulting in both biological and economic benefits.

40. Yields may also be increased through the practice of stock enhancement. Increased yields from “enhanced” stocks are appropriate if attempts to enhance the stock above the natural level actually succeed, but not if the addition of artificially grown or seeded individuals simply replaces part of the natural stock itself.

41. There should be formal measures in place detailing how a fishery is managed on a rotational or enhanced basis. The individual circumstances of a rotational fishery and/or enhanced stock should be assessed to determine the extent to which the Harvest Strategy Standard should be modified in relation to that particular stock. The principles of specifying a target, soft limit and hard limit should be retained.

42. For fisheries managed on a rotational basis, the Harvest Strategy Standard should be applied with regards to the total stock size; however, temporary depletion of rotated areas should be allowed for, provided that these areas are capable of regenerating within a few years.

43. For enhanced stocks, the Harvest Strategy Standard should be applied using the biological reference points applicable to the natural stock. This means that the harvest strategy for the combined natural-plus-enhanced stock should incorporate a target based on MSY-compatible reference points or better,² and related soft and hard limits, all of which should be calculated relative to the natural stock alone. Thus the enhanced portion of the stock may be fully fished down.

Fisheries on highly migratory species or fisheries managed under an international agreement

44. The Ministry will generally rely on international organisations and agreements in which New Zealand participates to determine the status of highly migratory species (HMS) or other species or stocks under the purview of international organisations and agreements. Where an international organisation or agreement has adopted harvest strategies and rebuilding plans that meet or exceed the minimum standards contained herein, the approach of Ministry and Ministry representatives to the international organisation or agreement will generally be to support those strategies. In other situations, Ministry representatives will promote development and adoption by the international organisation or agreement of harvest strategies that meet or exceed the standards set out in the Harvest Strategy Standard. In particular, if an international organisation or agreement in which New Zealand is a participant does not have a process for developing a formal plan to rebuild a depleted stock, Ministry representatives will propose rebuilding strategies that meet or exceed the Harvest Strategy Standard for developing rebuilding plans.

45. In the cases of HMS or fisheries managed through an international organisation or agreement, there is a general requirement under international law to manage fisheries based on MSY-compatible reference points. In the absence of a TAC established by an international organisation or agreement, a TAC may need to be established under the Fisheries Act (1996) for the New Zealand portion of the stock within its Exclusive Economic Zone. In such a case, the Minister must act in a manner consistent with New Zealand's international obligations and the purpose of the Act. Any harvest strategy for the portion of the stock within New Zealand waters needs to consider a range of factors, including impacts on the stock as a whole.

Fisheries on section 14B stocks

46. For stocks listed under section 14B, the focus should be on the soft and hard limits rather than fishery or stock targets. A minimum standard for such cases is that the stock must be maintained at or above the soft limit of $\frac{1}{2} B_{MSY}$ or 20% B_0 , whichever is higher,⁴ with at least a 50% probability. Further, if the section 14B stock is believed to be near or below the hard limit of $\frac{1}{4} B_{MSY}$ or 10% B_0 , whichever is higher,^{4,11} steps should be taken to minimise or prevent catches of the section 14B stock until there is acceptable evidence that it has recovered at least to the soft limit of $\frac{1}{2} B_{MSY}$ or 20% B_0 , whichever is higher,⁴ with at least a 70% probability.^{12,13}

47. However, it should be noted that section 14B has never been invoked and appropriate management and scientific justification is needed before this happens.

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■ APPENDIX I. Glossary of Terms

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

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

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

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

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

Carrying capacity: The average **stock** size expected in the absence of fishing. Even without fishing the **stock** size varies through time in response to stochastic environmental conditions. See **B_0 : virgin biomass**.

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

CCAMLR: The Convention for the Conservation of Antarctic Marine Living Resources.

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

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

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

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

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

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

Fishing down: The consequence of fishing on a virgin stock is to reduce stock biomass down to an average level corresponding to an “optimal” rate at which the stock is to be exploited. The period over which fishing reduces the stock from its initial level to a target level is referred to as the **fishing down** phase.

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

$F_{\%SPR}$ (e.g. $F_{20\%}$, $F_{30\%}$, $F_{40\%}$): A level of fishing mortality that reduces the **spawning (biomass) per recruit** to x% of the unfished spawner-per-recruit (**SPR**) level.

Generation time: the average time taken for an individual to replace itself within a **stock** or **population**.

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

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

HMS: Highly Migratory Species.

Input controls: Refers to fisheries management regulations that limit the amount of effective fishing effort applied to fish stocks through, for example, restrictions on mesh size or related gear restrictions, closed areas and limits on vessel size and capacity (compare with **output controls**).

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

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

Maturity: Refers to the ability of fish to reproduce.

Management Strategy: A systems approach that links together a stock assessment process and management and monitoring controls, and sometimes also includes research and enforcement needs.

Management Strategy Evaluation: a procedure whereby alternative management strategies are tested and compared using simulations of fishery and **stock** dynamics.

Model: A conceptual and simplified idea of how the 'real world' works.

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

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

Output controls: Refers to fisheries management regulations that limit the amount of **catch** taken from fish stocks through, for example, the implementation of a **TAC**.

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

Overfished: Stocks that are below a biomass limit, such as the **soft limit**, are frequently referred to as "overfished" (e.g. in the United States). However, the term "**depleted**" should generally be used in preference to "overfished" because stocks can become depleted through a combination of **overfishing** and environmental factors, and it is usually impossible to separate the two.

Overfishing: Overfishing is deemed to be occurring if F_{MSY} (or relevant **proxies**) is exceeded on average.

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

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

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

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

Rebuilding plan: A series of catch or fishing mortality levels designed to rebuild a **depleted** stock (i.e. a **stock** that has fallen below the **soft limit**) back to the **target**.

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

Spawning Biomass: The total weight of sexually mature fish in a **stock** that spawn in a given year.

Spawning (biomass) per recruit (SPR): The expected lifetime contribution to the **spawning biomass** for the average recruit to a fishery. For a given exploitation pattern, rate of growth, maturity schedule and **natural mortality**, an **equilibrium** value of SPR can be calculated for any level of fishing mortality. SPR decreases monotonically with increasing fishing mortality. Refer to the Operational Guidelines Appendices for a more detailed explanation.

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

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

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

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

Sustainable Yield: the average catch that can be removed from a **stock** over an indefinite period without causing a further reduction in the **biomass** of the **stock**. This could be either a constant yield from year to year, or a yield that fluctuates in response to changes in abundance.

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

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

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

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

T_{min} : the number of years required to rebuild a **stock** in the absence of fishing; this is a function of three primary factors: the biology of the species, the extent of **stock depletion** below the target, and the prevailing environmental conditions.

Yield: Catch expressed in terms of weight.

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

■ APPENDIX II. Relationship of the Harvest Strategy Standard to Relevant Sections of the Fisheries Act 1996

1. The Harvest Strategy Standard is a technical standard to be used by the Ministry of Fisheries (“the Ministry”) when applying the legal provisions of the Fisheries Act 1996 (“the Act”) for the purpose of providing advice to the Minister of Fisheries (“the Minister”) related to the setting of TACs, and managing fisheries in accordance with the Minister’s decisions. It does not have legal force. Rather, it is a statement of how the Ministry intends to give effect to the obligations in the Act in the context of the practical requirements of managing fisheries. Sections 8, 10, 13, 14, 14A and 14B of the Act are of particular importance in this regard.

Sections 8 and 10

2. Section 10 of the Act (the Information Principles) is applicable to decisions relating to the setting of TACs. Fisheries management often involves decision-making on the basis of information that has a high degree of uncertainty. The Harvest Strategy Standard and the associated Operational Guidelines present means of dealing with varying levels of information about a stock. A best practice standard offers a means of minimising risk and enabling decisions that are consistent with the purpose of the Act as specified in section 8 – namely, “providing for the utilisation of fisheries resources while ensuring sustainability”.

Section 13

3. Section 13(2)(a) states that the Minister shall set a total allowable catch that “maintains the stock at or above a level that can produce the maximum sustainable yield, having regard to the interdependence of stocks”. Section 13(2A)(c) states that “if the Minister considers that the current level of the stock or the level of the stock that can produce the maximum sustainable yield is not able to be estimated reliably using best available information, the Minister must...set a total allowable catch ... (ii) that is not inconsistent with the objective of maintaining the stock at or above, or moving the stock towards or above, a level that can produce the maximum sustainable yield”. Maximum sustainable yield is defined in the Act as “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”. The Harvest Strategy Standard assists in meeting the requirements of sections 13(2)(a) and 13(2A)(c) by providing that fisheries should be managed to fluctuate around a target based on MSY-compatible reference points or better.²³

4. Section 13(2)(b) states that the Minister shall set a total allowable catch that ... “enables the level of any stock whose current level is below that which can produce the maximum sustainable yield to be altered (i) in a way and at a rate that will result in the stock being restored to or above a level that can produce the maximum sustainable yield, having regard to the interdependence of stocks; and (ii) within a period appropriate to the stock, having regard to the biological characteristics of the stock and any environmental conditions affecting the stock”.

²³ Refer to paragraphs 16-17 of the main text for the definition of the phrase, “MSY-compatible reference points or better”.

5. The Harvest Strategy Standard assists in decision-making under this section by providing that depleted stocks should be rebuilt back to a target based on MSY-compatible reference points or better,²³ and ensuring that the specified rate of rebuilding takes due account of relevant biological and environmental factors. In section 13(3), it is also stated that when deciding on the way and rate at which a stock is rebuilt ... “the Minister shall have regard to such social, cultural, and economic factors as he or she considers relevant”. The Harvest Strategy Standard allows rebuilding plans to take these factors into account by enabling the adoption of targets “better than” MSY-compatible reference points, and permitting flexible rebuilding timeframes.

6. Section 13(2)(c) states that the Minister shall set a total allowable catch that enables the level of a stock above B_{MSY} ... “to be altered in a way and at a rate that will result in the stock moving towards or above a level that can produce the maximum sustainable yield, having regard to the interdependence of stocks.” The approach specified in the Harvest Strategy Standard is that fisheries should be managed so that stocks above MSY-compatible reference points are either decreased or increased towards a specified target based on MSY-compatible reference points or better.²³ However, experience in New Zealand and elsewhere indicates that caution should be exercised during the “fishing down” phase of a fishery. The Harvest Strategy Standard specifies how this can be achieved.

Sections 14 to 14B

7. Section 14 states that the Minister may, if satisfied that the purpose of the Act would be better achieved by setting a TAC otherwise than in accordance with section 13, set a TAC that the Minister... “considers appropriate to achieve the purpose” of the Act. A species may be listed under section 14 of the Act if:

- “(i) It is not possible to estimate B_{MSY} because of the biological characteristics of the stock;
- (ii) A national allocation has been determined as part of an international agreement;
- (iii) The stock is managed on a rotational or enhanced basis; or
- (iv) The stock is a highly migratory species.”

8. Section 14 differs from section 13 in a number of significant ways. It clearly envisages that a TAC may be set other than on the basis of section 13. This suggests that the objective need not be to achieve targets based on MSY-compatible reference points or better.²³ There is no reference to the interdependence of stocks or the need to rebuild a depleted stock, nor any express requirement to take into account social, economic and cultural considerations.

9. However, the overriding purpose when setting a TAC other than in accordance with sections 13(2) and 13(2A) is still “to provide for the utilisation of fisheries resources while ensuring sustainability” (section 8). Thus, all fisheries should be managed so that there is a high probability of achieving targets and a very low probability of breaching limits. The approach of the Harvest Strategy Standard in respect of section 14 is that the three core components of the Harvest Strategy Standard (a specified target, a soft limit and a hard limit) should form the basis for TAC setting for section 14 stocks, but that the target and the soft limit, and

management actions associated with them, may be modified in certain instances. While a target may differ from MSY-compatible reference points or better,²³ the best practice principles of identifying target and limit reference points are equally applicable to section 14. In particular, the default hard limit specified in the Harvest Strategy Standard should generally be retained as the absolute minimum sustainability standard.

10. Section 14A sets out the conditions for listing stocks under section 14B, which states that the Minister must set a TAC that is “no greater than that which will allow taking of another stock or stocks in accordance with the TAC and TACC set for that other stock or stocks”, and in all instances the TAC that is set must maintain the stock “above a level that ensures its long-term viability”. In practice, sections 14A and 14B allow catches of key target species to be maintained without being unduly constrained by the need to apply targets based on MSY-compatible reference points or better²³ to minor bycatch stocks.

11. Section 14B of the Act can only be applied where the Minister is satisfied, pursuant to section 14A(5), that:

- “(a) The stock is taken primarily as an incidental catch during the taking of one or more other stocks and is only a small proportion of the combined catch of the stock and other stocks or stocks;
- (b) The total benefits of managing the stock at a level other than that permitted under section 13 outweigh the total costs;
- (c) Managing the stock at a level other than that permitted under section 13 will have no detrimental effects on non-commercial fishing interest in that stock;
- (d) The stock is able to be maintained above a level that ensures its long-term viability; and
- (e) The purpose of the Act would be better achieved by setting a TAC otherwise than in accordance with section 13.”

12. The Harvest Strategy Standard assists in decision-making under section 14B by providing that, while fisheries do not need to fluctuate around targets based on MSY-compatible reference points or better,²³ stocks should be maintained above the soft limit and prevented from falling towards the hard limit.

General points in respect of TAC decisions

13. The identification of targets (based on biomass or fishing mortality rate or catch levels, or proxies for these) provides clear reference points for assessments of the status of fish stocks. The adoption of a target ensures that a consistent approach is taken to the management of QMS fisheries, in line with the specific factors to be taken into account under sections 13 and 14.

14. In support of section 13, the Harvest Strategy Standard stipulates that when the current TAC is clearly above the level that enables the desired target level to be achieved, or when there is a reason to believe that either the soft or hard limit has been breached, or may be in the near future, the TAC should be reduced to facilitate stock rebuilding (subject to other relevant factors being taken into account as required under the Act). This is consistent with the purpose of the Act and represents best practice in rebuilding depleted stocks.

15. The Act does not stipulate that a stock must be closed to fishing at any particular biomass level. The Minister is, however, legally able to set a TAC at zero. The decision on when to do so is discretionary, subject to due consideration of relevant factors. The default hard limit in the Standard is the level at which the closure of a fishery will be recommended to the Minister as a matter of general practice, unless there are compelling reasons not to do so.

Other definitional issues

16. The terms “rotational” and “enhanced” are not defined in the Act but should be understood in a manner consistent with their common meanings in a fisheries context. A rotationally managed fishery is one that has a planned cycle of selectively harvesting different areas occupied by a stock. An enhanced stock is one where individuals of a species are artificially grown and returned to the wild stock, or areas are re-seeded through human intervention. This should result in the wild stock being enhanced beyond a level that can be produced by natural processes alone. However, this does not mean that a stock can be reduced below the level of the MSY-compatible reference points applicable to the natural stock, but rather that the increased biomass may enable a higher catch level, if the enhancement is successful.

17. To be effective, management on a rotational or enhanced basis must be compatible with the biological characteristics of the species concerned. Generally, rotational harvesting is only appropriate for short-lived, highly productive sessile or semi-sessile species. There should be formal measures in place that detail how a fishery is managed on a rotational or enhanced basis. For fisheries managed on a rotational basis, the Harvest Strategy Standard should apply with regards to the total stock size, but not necessarily to individual areas. For enhanced stocks, the Harvest Strategy Standard should be applied using the biological reference points applicable to the natural stock. The Harvest Strategy Standard specifies how this can be achieved.

18. The Act does not expressly refer to terms such as “target”, “limit” or “formal, time-constrained rebuilding plan”. However, the use of these terms is consistent with the purpose of the Act and is appropriate in a fisheries management context, given the practical requirements of managing fisheries and best practice considerations.

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