HARVEST STRATEGY POLICY AND OPERATIONAL GUIDELINES FOR THE AQUATIC RESOURCES OF WESTERN AUSTRALIA

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Harvest Strategy Policy and Operational Guidelines for the Aquatic Resources of Western Australia.

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1.0 EXECUTIVE SUMMARY

Harvest strategies establish the decision rules that determine the appropriate harvest levels for all sectors to meet the ecological, economic and social objectives established for a resource. The development and implementation of formal harvest strategies is considered sound practice in contemporary fisheries management. A number of recent legislative (new Aquatic Resources Management Act, ARMA) and policy (Marine Stewardship Council, MSC) initiatives require the development of formal harvest strategies for the key aquatic resources in Western Australia (WA).

To ensure harvest strategies are developed in a consistent and efficient manner, the Department of Fisheries (Department) has developed a Harvest Strategy Policy (the Policy) for use with the management of aquatic resources of WA. This policy and its associated operational guidelines outline the core elements that must be included within each harvest strategy and the set of issues that must be considered when they are being developed.

Within WA, there is a broad scope of aquatic resources subject to direct management arrangements and the types of objectives to be achieved from their use are also varied. Consequently, to ensure an integrated approach, the Policy not only covers the management of target species abundance but it also incorporates social and economic considerations such as sectoral allocations plus the management of unacceptable risks to other ecological resources. Consequently, the definition of a 'harvest strategy' for WA's purposes is:

A harvest strategy establishes clear and specifically articulated performance levels and associated management actions designed to achieve the agreed objectives for the resource and relevant fishery sectors.

Where a harvest strategy is required, the core elements are:

1. Articulation, at an operational level, of what is to be achieved, and why, both for the resource and the relevant fisheries (**operational objectives**);
2. Determination of performance **indicators** to be used to measure performance against operational objectives;
3. Based on achieving **acceptable risk levels**, establishment of appropriate **reference points/levels** for each performance indicator;
4. The selection of:
    - the most appropriate **Harvesting Approach** (e.g. constant harvest/exploitation, constant escapement/stock size, constant catch);
    - the associated **Harvest Control Rules** which articulate pre-defined, specific management actions based on current status designed to adjust fishing intensity (catch/effort) to either maintain target levels and avoid breaching thresholds/limits or return to acceptable levels in an appropriate timeframe; and
    - the **Allowable Catch/Effort Tolerance** which is used to evaluate the effectiveness of the management actions in delivering the specific catch/effort as determined by the Harvest Control Rules and IFM allocation decisions;

5. **Monitoring and assessment procedures** for the collection and analysis of all the data needed to underpin the harvest strategy and determine stock status and fishery performance against operational objectives; and
6. The timetable and frequency for **Review** of the harvest strategy elements.

In addition to the core elements outlined in the Policy, the associated guidelines discuss the main features that need to be considered when developing an effective harvest strategy. Given, the broad scope of the Policy, while it is consistent with the National Harvest Strategy Guidelines, it also covers bycatch, protected species, etc. which obviates the need to have separate policies for these components because the same management principles apply.

The development of harvest strategies in WA will be based on the risk status of the resource and those of any dependent fisheries, and other relevant matters such as legislative and MSC assessment requirements. For most target species, the determination of risk will be completed using quantitative stock assessments. The assessment of risks for the other ecological categories (by-product, by-catch, habitat and ecosystems) and for social and economic objectives will use international standard (ISO 31000, 2009) qualitative risk assessment procedures developed for the risk based management of fisheries.

For the development of a harvest strategy for a particular resource, indicators will be selected to describe performance in relation to the operational objectives using a set of reference levels that separates acceptable performance from unacceptable performance. Where relevant, these levels can include:

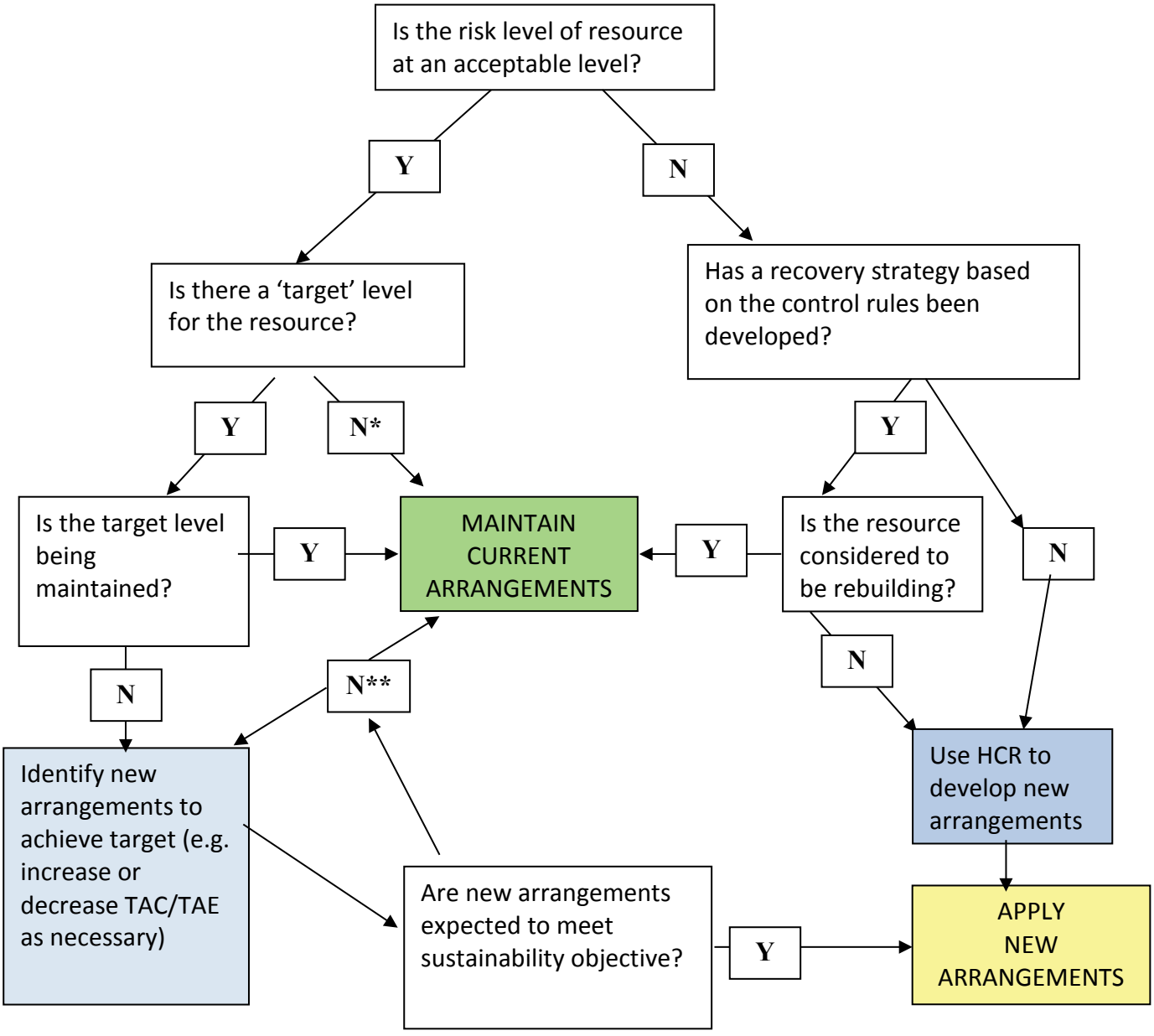
- a target level (where you want the indicator to be);
- a threshold level (where you review your position); and
- a limit level (where you don't want the indicator to be).

Not every resource will require a harvest strategy that has all three reference levels or that covers all three types of objectives (ecological, social and economic). The only compulsory performance reference levels will be those used to assess stock/ecological sustainability. Specific performance levels and associated control rules will only be adopted for social and economic objectives where there is a practical advantage, suitable information and broad agreement from the relevant industry sectors. Having the appropriate data collection systems in place will also be necessary which is particularly important when considering specific objectives for recreational fisheries.

The Harvest Control Rules (HCRs) define what management actions should occur to meet the agreed objectives for the resource based on the current or likely future levels in relation to (where relevant) the limit, threshold or target levels plus any IFM based, allocation decisions. These pre-defined management actions are designed to maintain a resource above their threshold level (and where relevant, close to a target) or rebuild it where it has fallen below this (undesirable) or the limit (unacceptable) levels. Where a resource is rebuilding from undesirable or unacceptable levels, additional reference levels may need to be established to define an appropriate rate of recovery (Exec Summary Fig. 1).

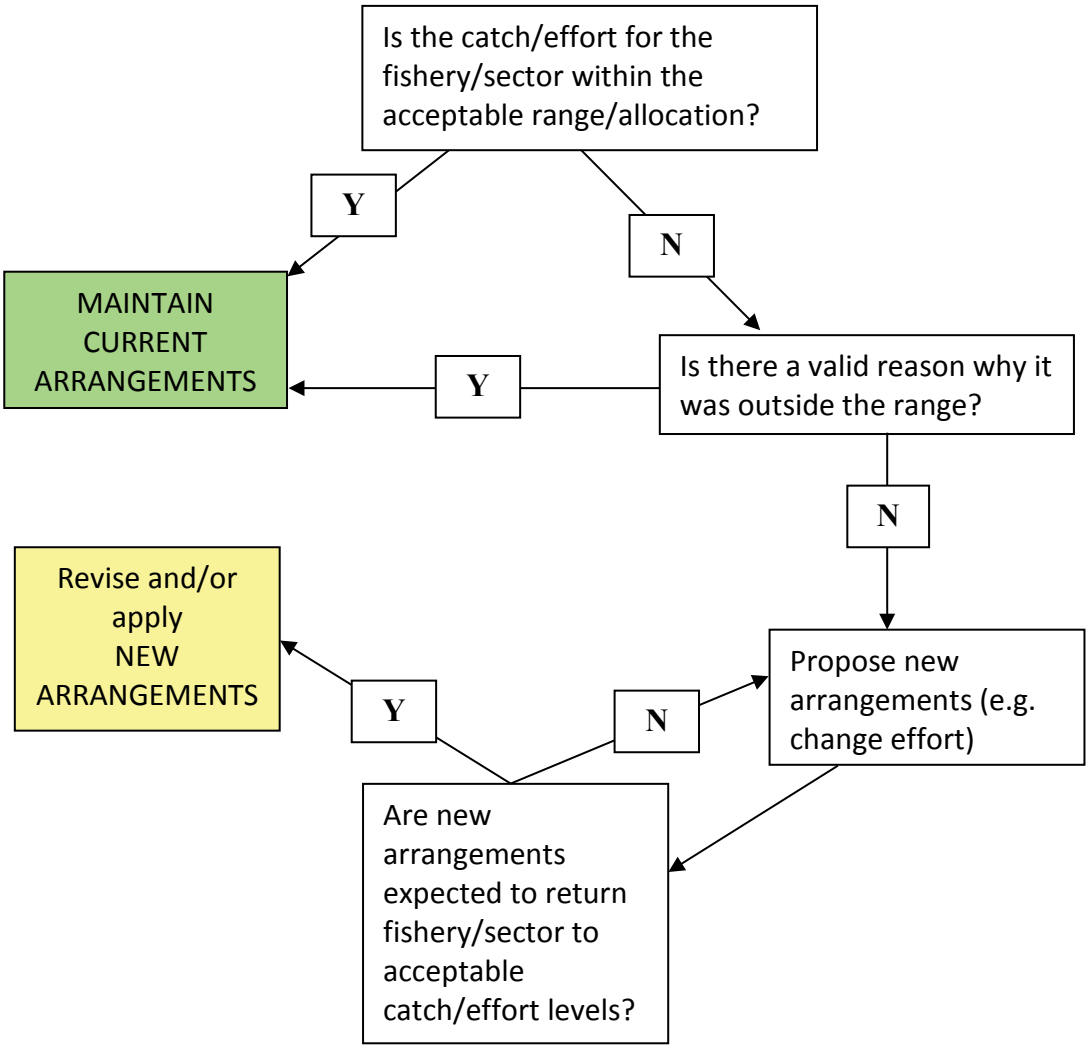
To minimise interventions and provide greater certainty for when management adjustments may be required, the Allowable Catch/Effort tolerance levels establish what range of deviations in annual catch or effort will be considered acceptable in meeting the levels specified either by the HCRs to meet stock based objectives and/or to meet any sectoral allocations as developed by IFM determinations (Exec Summary Fig. 2).

Aquatic resources (and fisheries) covered by harvest strategies will each be subject to regular review. The frequency and comprehensiveness of these will be determined by a combination of their current risk status, relative value and the life history characteristics of the resource.



Exec Summary Fig. 1 - Decision tree for regular review of resource status

Note the term "New Arrangements" can include the addition or change to any of the activities associated with the management process.
*The decision tree recognises that not all operational objectives currently have target levels.
**If no new set of arrangements meets the primary sustainability objective then the previous arrangements that did meet this objective would be maintained.



Exec Summary Fig. 2. Decision tree for regular review of fishery status – based on allowable catch/effort tolerance levels and any sectoral allocation decisions.

1.1 Glossary and Abbreviations

Acceptable Catch/Effort/Catch Rate: Where the annual catch, effort or catch rate for a fishery is within the Catch/Effort/Catch Rate range (as determined by the allowable catch, effort or catch rate tolerance) or there is an appropriate reason for this not to have occurred.

Acceptable Performance: the indicator is 'above'[1], and will remain 'above' the threshold level with an appropriate level of certainty.

Acceptable Risk Levels: The levels of risk associated with an objective (normally moderate or lower) considered acceptable for meeting government and community expectations.

Adequate Stock level: Describes when the spawning stock indicator(s) is/are above the threshold level.

Allowable Catch/Effort/Catch Rate Tolerance: The agreed deviation (either in terms of a % or an absolute level) in catch, effort or catch rate values that will be considered as meeting the levels as defined by the harvest control rules and/or relevant sectoral allocation decisions. This determines how the acceptable catch/effort or catch rate range for a fishery should be calculated.

ARMS: Aquatic Resource Management Strategy.

ARUP: Aquatic Resource Use Plan.

Biomass: the total weight estimate of a stock, or of a component of a stock.

Breeding Biomass: (also referred to as spawning stock biomass) the total weight estimate of all mature females in a population.

Constant Escapement/Stock Size: harvesting approach where the catch or effort is adjusted annually to ensure a certain minimum proportion of the stock always remains at the end of each season or the spawning period.

Constant Exploitation: harvesting approach where the same proportion of the available stock is taken each year. The annual catch rises and falls in proportional to variations in stock abundance.

Constant Catch: harvesting approach the annual catch level is relatively small compared to stock levels and therefore unaffected by normal levels of recruitment variation (e.g. south coast pilchards).

Egg Production: the total quantity of eggs or progeny that will be produced by a stock in a single spawning year.

[1] Where 'above' is interpreted as the indicator being in on the acceptable side of the reference level; i.e. it may be either greater (e.g. for B) or lower (e.g. for F) depending on the specific indicator.

Harvest Control Rules: pre-defined specific management actions to maintain target (catch/effort/catch rate) levels and/or avoid breaching thresholds or limits.

Harvest Strategy: establishes clear and specifically articulated performance levels and the associated set of management actions designed to achieve each of the agreed objectives for the resource and relevant fishery sectors.

Inadequate Stock Level: Describes when the spawning stock indicator(s) is/are below[2] the threshold level. This covers both undesirable and unacceptable stock levels.

Indicator: A measure of some aspect of performance related to one or more objectives (often called performance indicator).

Indicator Species: To accommodate the numerous multispecies finfish fisheries in WA, the strategy that has been adopted is for one or more indicator species to be used to monitor the status of the entire suite of species. Even if only one of the indicator species has breached the threshold or limit level then the entire suite of species is deemed to have breached this level[3].

IFM: Integrated Fisheries Management.

ITQ: Individual Transferable Quota.

ITE: Individual Transferable Effort.

Limit Reference Level: an upper or lower boundary of a biological, economic or social indicator. If the indicator value falls outside the limit it triggers immediate significant management action.

Management strategy assessment (evaluation): a procedure (either qualitative and/or quantitative) whereby alternative management strategies are explicitly compared.

Maximum Economic Yield (MEY): the theoretical catch or effort level for a commercial fishery that maximises average net economic returns over a number of years. Fishing to MEY will usually result in the equilibrium stock (biomass) of fish being larger than that associated with MSY.

Maximum Sustainable Yield (MSY): the theoretical maximum sustainable average annual catch that can be removed from a stock over an indefinite period under prevailing environmental conditions.

Marine Stewardship Council (MSC) – is an independent third party body that has generated a set of standards for sustainable fishing.

Not Desirable: indicator is 'below' (2) the threshold level but 'above'(1) the limit level.

Operational Objectives: are the clear articulations, of what is to be achieved by the harvest strategy specifically for the fishery and stock.

[2] Where 'below' is interpreted as being on the unacceptable side of the reference level.
[3] See DOF (2011) Resource assessment framework for finfish resources in Western Australia. Fisheries Occasional Publication No. 85 for more details.

Optimal performance: when the indicator is suitably close to the target level based on being within an agreed tolerance level.

Overfishing: when a stock is experiencing too much fishing and the removal rate from the stock is too great to achieve one or more objectives. **Growth overfishing** occurs when fish are being harvested at an average size that is smaller than the size that would produce the maximum sustainable yield. **Recruitment overfishing** occurs when the spawning stock biomass is being depleted at a rate that, if it continues, would lead to (or has led to) the stock level being overfished.

Overfished: when a stock has experienced too much fishing and it is currently below one or more of its limit reference points and there is now a high risk of future recruitment levels being measurably reduced (see also recruitment impairment).

Quota: The total level of catch allowed to be taken or effort allowed to be used.

Performance indicator: A performance indicator is a quantity that can be measured and used to track changes with respect to achieving an operational objective. Performance is measured by comparing where a performance indicator currently sits in relation to a reference level.

Population: The entire set of potentially interbreeding individuals of a species. A population may have a number of sub-population or stocks.

Precautionary Approach: in cases where there is a reasonably high probability (but not full certainty) of an undesirable outcome occurring, actions should be taken immediately. It does not mean, however, (as it has sometimes been misinterpreted) that full certainty about all potential impacts is required before an activity can proceed.

Recruitment Impairment: MSC term for the stock level when recruitment will be adversely affected.

Recruitment into fishery: the entry of an age or size class of fish into the susceptible (legal) component or area of a fishery (i.e. able to be caught and kept).

Recruitment into stock: the absolute or relative number of juveniles entering the stock at the age or size class where density dependent survival is now minimised.

Recruitment Overfishing: see overfishing.

Recovering (Rebuilding): this describes situations where the indicator is still below the threshold or limit level but a recovery plan has been implemented and there is evidence or a reasonable expectation that recovery is now occurring at an acceptable rate due to the additional management actions and/or natural processes.

Reference Level: see Target, Threshold and Limit reference levels.

Risk: "*the uncertainty associated with achieving objectives*" from ISO 31000 (2009) which is generally measured as Consequence x Likelihood (AS HB 89, 2012).

Spawning potential: total potential egg production of a stock or population. This is often measured using spawning stock or breeding biomass or some other abundance based surrogate/proxy.

Spawning Stock Biomass: see Breeding Biomass.

Stock: a functionally discrete population that is sufficiently distinct from other stocks or populations of the same species for the purposes of fisheries/resource management.

Stock Sustainability reference level: The reference values developed to achieve stock sustainability based on the principle that there are levels of spawning potential or spawning stock biomass above which recruitment should not be significantly affected by the current stock size.

Suite: For EBFM monitoring and assessment processes, five ecological suites of captured species are utilised based on broad habitat and depth criteria - Estuarine, Nearshore, Inshore Demersal, Offshore Demersal and Pelagic (see also indicator species).

TAC: Total Allowable Catch.

TACC: Total Allowable Commercial Catch.

TACE: Total Allowable Commercial Effort.

TAE: Total Allowable Effort.

TARC: Total Allowable Recreational Catch.

TARE: Total Allowable Recreational Effort.

Target Reference Level: The optimum value (which must be above the biological threshold level), range or direction for an indicator(s) to deliver economic and/or social objectives.

Threshold Reference Level: an upper or lower boundary of an indicator, outside of which additional management actions may be required to avoid breaching the limit level.

Unacceptable performance: The indicator is 'below'[(see foonote 2 previously)] the limit level.

Undesirable performance: The indicator is below the threshold but above the limit.

Uncertainty: The level of error in the measurement or estimation of an individual indicator or the outcomes from a quantitative assessment. It can also reflect the level of robustness of the indicator in measuring performance of the operational objective. Finally it can relate to the number of alternative scenarios, possible states or outcomes for a stock where qualitative likelihoods or quantitative probabilities are assigned to each possible state or outcome related to risk assessment outcomes.

2.0 INTRODUCTION

2.1 Context and Purpose

The objects of the *Fish Resources Management Act 1994* (FRMA) include *"to conserve fish and protect their environment"*, "*to ensure that the exploitation of fish resources is carried out in a sustainable manner*" and "*to achieve the optimum economic, social and other benefits from the use of fish resources*". Similarly, the proposed new ARMA includes objects to: *(a) ensure the ecological sustainability of the State's aquatic resources and aquatic ecosystems for the benefit of present and future generations; and (b) to ensure that the State's aquatic resources are managed, developed and used having regard to the economic, social and other benefits that the aquatic resources may provide.*

These instruments provide the legal basis for fisheries in WA to be managed under the principles of Ecologically Sustainable Development (ESD; CoA, 1992; DoF, 2002). To effectively deal with community expectations for aquatic resource management in the 21st Century, translation of these legislative objectives into clearly defined operational arrangements and procedures is required. Documenting how the specific management arrangements for each resource/fishery should be adjusted to achieve acceptable performance against these operational objectives given the current status is commonly referred to as a Harvest Strategy or a Harvest Policy (Cadrin & Pastoors, 2008)[4]. The development and implementation of formal harvest strategies is considered sound practice in contemporary fisheries management.

To ensure a consistent and effective approach to the development of harvest strategies in WA, a *Harvest Strategy Policy and Operational Guidelines for the Aquatic Resources of Western Australia* (the Policy) has been developed. Using a harvest strategy based approach is particularly important for managing resources and fisheries with a diversity of stakeholders that may have competing values and differing expectations.

While consistent with National Harvest Strategy Guidelines (Sloane et al; 2014), as envisaged in these guidelines the Policy includes additional elements necessary to meet WA requirements including the proposed new ARMA. Given the WA Government's policy initiative for all commercial fisheries to obtain third party certification through the MSC, the policy is also consistent, to the extent possible, with MSC guidelines and terminology.

The Policy will be progressively applied to all relevant resources and fisheries in WA over a five year timeframe as part of the schedule for the development and/or review of each resource/fishery. It will be reviewed at the end of this five year period which will provide the opportunity to update any elements in light of issues that may have arisen in its application or to accommodate shifts in aquatic management.

2.2 Background

Since the *Fisheries Act 1905*, the goals and operational intent of the Department has been the sustainable use of aquatic resources. In recent decades there has been growing public expectation for improved accountability in the management of natural resources by having greater transparency in the assessment of fishery and aquaculture management performance.

[4] This has also been referred to as a Management Strategy in some countries.

This includes external scrutiny by State and Commonwealth Governments including, for example, assessments under the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC; CoA, 2007b) and, more recently, through independent third party assessment such as Marine Stewardship Council (MSC) certification.

Over the past decade, the Department has been adopting policies to implement the principles of ESD for WA fisheries (DoF, 2002[5]) and to explicitly share access among sectors through integrated fisheries management (IFM; DoF, 2000; Fletcher & Curnow, 2002). These concepts have more recently been expanded to the adoption of a regional level, risk based framework (Fletcher, et al., 2010, 2012) that is consistent with the resource level approach proposed within the ARMA. This represents one of the first full implementations of Ecosystem Based Fisheries Management (EBFM) in the world (Fletcher et al., 2012; Cochrane et al., 2014).

Successfully implementing EBFM has required each resource and fishery level objective to be identified and their associated risk levels determined (Fletcher et al., 2011, 2012, Fletcher, 2005; 2015). The set of ecological risks associated with each of the meso-scale ecosystems, habitats, and captured species within each of WA's six bioregions are now annually assessed and reported within the *Status Reports on the Fisheries and Aquatic Resources of Western Australia* (e.g. DOF, 2012b).

Under the proposed ARMA, each aquatic resource (including targeted and non-targeted ecological resources) that is to be moved to "managed resource" status following a risk assessment will require an Aquatic Resource Management Strategy (ARMS) and one or more associated Aquatic Resource Use Plans (ARUP). Developing ARMS and ARUPs involves the translation of relevant high level objectives into a practical operational plan for each of the relevant resources or sectors including the development of formal harvest strategies.

3.0 WHAT IS A HARVEST STRATEGY?

3.1 Origins

The concepts and drivers for developing harvest strategies were originally advanced to enable better implementation of adaptive (Hilborn & Walters, 1992) and precautionary approaches[6] to fisheries management (Mace, 1994; Garcia, 1996; Rosenberg & Restrepo, 1996). These were designed to improve the utilisation of the outputs of stock assessments for target species within the management of USA fisheries (NRC, 1998, 2001). The basic concepts include:

- the identification of alternative harvesting approaches (constant harvest/exploitation rate, constant escapement/stock size and constant catch),
- the requirement to establish precautionary reference points,
- a set of harvest decision and control rules that describes how fishing exploitation should be adjusted as a function of changes in spawning potential or stock size.

[5] This was based on the national ESD Framework (Fletcher et al., 2002) and is consistent with the FAO standard for Ecosystem Approach to Fisheries (EAF; FAO, 2005; Fletcher and Bianchi, 2014)

[6] The Precautionary Approach is defined as "*in cases where there is a reasonably high probability of an undesirable outcome occurring, actions should be taken immediately.*" ***It does not mean,*** *however, (as it has sometimes been misinterpreted)* ***that full certainty about all potential impacts is required*** *before an activity can proceed* (FAO, 1996, DoF, 2002).

Based on these principles, specific harvest strategy policies and guidelines have been developed in a number of non-USA jurisdictions including for Commonwealth managed fisheries in Australia (CoA, 2007a), New Zealand (NZ Gov., 2008a, b) and elsewhere (Cadrin & Pastoors, 2008).

3.2 Previous use of Harvest Strategies in WA

Many of the elements required for formal harvest strategies are already used in WA. The Department's ESD policy (DoF, 2002) has for the past decade required each fishery to have operational objectives that were '*consistent with, and clearly linked to higher level objectives'*. The ESD policy also required identification of suitable indicators to monitor 'performance' and 'performance measures' (e.g. limits/thresholds) to assess whether each of the operational objectives for an individual fishery was being achieved. In addition, it required articulation of the proposed set of *management actions* that were to be used to achieve acceptable performance and the '*actions if a performance measure limit is exceeded'*. Finally, in its timetable for actions, the ESD policy identified the need for a document that would include '*agreed benchmarks and standards for the assessment of performance*'.

A number of commercial fisheries in WA have published fishery-level harvest strategies (e.g. Rock Lobster, Donohue et al., 2010, DoF, 2012c; Abalone, Hart et al., 2009). A number of other fisheries have management plans that operate under sophisticated, but until recently, unpublished harvest strategies that both minimise environmental risks but also aim to optimise economic returns (e.g. Exmouth Gulf Trawl, Shark Bay Trawl, Pearl Oysters). The development and adoption of this formal policy for Western Australia therefore represents a continuation and refinement of the Department's ESD fisheries policy.

4.0 HARVEST STRATEGIES FOR WA

4.1 Definition and core elements

Given the wide appeal of this approach within Australia, a review of current harvest strategy practices has recently been undertaken by the Australian Fisheries Management Forum (AFMF) from which a set of national guidelines for harvest strategy development has been developed (Sloan et al., 2014). This review determined that, while general principles may be identified and agreed, the inherent differences in legislative scope across the nation, geography, as well as local social and economic drivers will generally require the development of specific policies that reflect the individual needs and values of each State/Territory/Commonwealth jurisdiction.

The WA Policy is, therefore, consistent with these National Harvest Strategy Guidelines but it includes the additional elements necessary to meet the specific requirements of WA (e.g. EBFM and IFM). Furthermore, because the same management principles apply, the Policy will also cover the development of 'strategies' to deal with unacceptable risks to other ecological resources (e.g. bycatch)

The definition adopted for a harvest strategy in WA, therefore, is that:

> **A harvest strategy establishes clear and specifically articulated performance levels[i] and associated management actions[ii] designed to**

achieve the agreed objectives[iii] for the resource and relevant fishery sectors.

i. *This can include target, threshold and limits which may involve specific point values, a range of values, or even a direction*
ii. *This includes all harvest control rules plus the monitoring and assessment programs*
iii. *"objectives" include all ecological objectives and, where developed, any agreed social and economic objectives.*

The main target or indicator species for each fishery will automatically have a formal harvest strategy. The decision as to whether other aquatic resources potentially impacted by the fishing activities will require formal harvest strategies will be based on the combination of the current risk levels of the resource (generally only medium risk or above) and the relative social and economic values generated from the use of the resource by any associated fishery or other stakeholder sectors.

Where a formal harvest strategy is required, the core elements are:

1. Articulation, at an operational level, of what is to be achieved, and why, both for the resource and each of the relevant fisheries and sectors (**operational objectives**);
2. Determination of the performance **indicators** to be used to measure performance against operational objectives;
3. Based on achieving **acceptable risk levels**, establishment of appropriate **reference points/levels** for each performance indicator;
4. The selection of:
   - the most appropriate **Harvesting Approach** (e.g. constant harvest/exploitation, constant escapement/stock size, constant catch);
   - the associated **Harvest Control Rules** which articulate pre-defined, specific management actions based on current status designed to adjust fishing intensity (catch/effort) for each fishery/sector to either maintain target levels and avoid breaching thresholds/limits or return to acceptable levels in an appropriate timeframe; and
   - the **Acceptable Catch/Effort Tolerance** for each fishery/sector which is used to evaluate the effectiveness of the current management arrangements in delivering the catch/effort required by the Harvest Control Rules and/or IFM allocation decisions;
5. **Monitoring and assessment procedures** for the collection and analysis of all the data needed to underpin the harvest strategy and determine stock status and fishery performance against operational objectives; and
6. The timetable and frequency for **Review** of the harvest strategy elements.

In addition to these six core elements, the remainder of the Policy and its associated guidelines outlines each of the main features that need to be explicitly considered when developing an effective harvest strategy.

4.2 Specific WA policy requirements

The Policy developed for WA incorporates many of the concepts contained in similar guidelines and polices in other jurisdictions (e.g. Sloan et al., 2014). It has, however, also been specifically drafted to incorporate the Department's Integrated Fisheries Management (IFM) approach (IFM; DoF, 2000; Fletcher and Curnow, 2002) and the regional, EBFM

framework (Fletcher, et al., 2010, 2012). Importantly, it can operate under the existing FRMA or the new ARMA. The policy is also consistent with the Commonwealth's EPBC "*Guidelines for ecologically sustainable management of fisheries"* (CoA, 2007b) through which all export fisheries are assessed. With the adoption by Government of the MSC to promote third party certification of all commercial fisheries in WA and the move to national status reporting (Flood et al., 2012), where possible, MSC criteria and nationally agreed Common Language, guidelines and terminology have been used. A detailed comparison of the Policy with these other systems is provided in Appendix 1.

4.3 Scope of WA policy

The ARMA requires establishment of ARMS for each managed aquatic resource. Each ARMS will use the EBFM approach of incorporating ecological, social and economic objectives within a risk based, decision making framework including:

- a definition of the biological resource(s) that it covers,
- the spatial scale over which the strategy applies (region and/or ecosystem);
- the set of overall objectives for the management of these resources and parameters for their use (DoF, 2010); and
- the allocation of access to the resource by the different fishing sectors (IFM).

Consequently, when the resource subject to an ARMS is effectively just a single stock (e.g. western rock lobster), a single harvest strategy can simply deal with all the sectors accessing this stock. The definition of a resource within an ARMS may, however, be more broadly defined (e.g. the invertebrate resources of Shark Bay) and cover multiple target species (two prawn species, scallops and crabs) that are being fished with different gears (two types of trawl gear and a trap gear) by different, but overlapping fleets. In this case, the harvest strategies that are developed need to account for the interaction of operations on the individual species, gears and sectors to generate an outcome which produces the best overall EBFM outcome for the entire 'resource'. The clear benefit in adopting the ARMS approach is that this not only ensures that all the take from each of the stocks is properly considered and dealt with, but by defining resources more broadly where stocks/fisheries have clear and significant interlinkages, a cohesive EBFM outcome through linked harvest strategies can be obtained.

In developing the ARMS, the primary management objective will no longer be just ensuring key target stocks remain above a threshold level that avoids direct impacts on future recruitment. Consistent with the requirements for MSC certification, the Policy requires the management of commercially-fished fisheries in WA to identify a suitable target level, range or direction for these stocks that is above the B_{MSY} level. Management strategies based upon achieving and maintaining a target level for stock size are more precautionary than just being above a threshold which should ultimately be more cost effective for both the Department and industry because there should be less need for urgent management interventions (Walters and Martell, 2004).

While in most jurisdictions, harvest strategies have to date only been applied to manage the abundance levels of target stocks for commercial fisheries, the development of ARMS may require harvest strategies to cover other resources and other sectors. The management of risks to the other components such as by-product species, bycatch species, threatened, endangered and protected species, habitat and ecosystem elements may also need to be considered when developing appropriate target species management arrangements. Moreover, specific

'harvest' strategies that directly ensure the risks to these components are kept at acceptable levels may need to be developed. The broader scope of the Policy obviates the need to have separate bycatch, protected species, etc., policies because the management principles are the same for all these resources.

Table 1. Relationship between the requirements outlined for the development of an Aquatic Resource Management Strategy and the components developed under the Harvest Strategy Policy.

ARMS	Relationship with Policy
Description of resource	Input to HS
Objective to Achieve	Convert to operational objective Determining acceptable risk levels
Minimum quantity of resource necessary to be maintained	Defining ecological threshold reference point(s)
Activities to be regulated	Input to HS
Period for regulating activities	Input to HS
Method to be used in calculating 'TAC'	Monitoring and Assessment Procedures and harvest controls rules, tolerance levels
Proportion of TAC for recreational purposes	Input for determining annual acceptable catch/effort for sector
Proportion of TAC for commercial purposes (target and incidental)	Input for determining annual acceptable catch/effort for sector(s)
Number of shares for commercial sector	Used for post HS calculations
Scientific parameters to assess management	Determining indicators and establishing target, threshold and limit reference points
Consultation for ARUP to implement ARMS	Input as to how HS will be developed for each resource/fishery

4.4 Determining when the Policy will be applied

It is recognised that the assessment and management of risks is a critical part of any system designed to achieve fisheries objectives (Fletcher, 2005, Fletcher & Bianchi 2014; Fletcher, 2015). The Department has therefore adopted a formal, bioregional level, risk-based management framework to guide its activities (Fletcher et al., 2010; 2012) based on the international standards for risk management and risk assessment (ISO 31000, 2009; SA HB 89, 2012). The standard definition of risk "*the impact of uncertainty on achieving objectives*" (ISO, 31000; 2009) is therefore used. Similarly, all risk analyses involve determining, based on current or proposed management arrangements (risk controls), what potential consequences could occur associated for each objective and the likelihood that each of these consequence levels will actually occur (SA HB 89, 2012). The higher the likelihood (probability) that a 'worse' consequence for an objective will actually occur, the greater is the level of risk (see Fig. 1 and Table 1).

		Likelihood				
Consequence		Remote (1)	Unlikely (2)	Possible (3)	Likely (4)	Certain (5)
	Negligible (0)	0	0	0	0	0
	Minimal (1)	1	2	3	4	5
	Moderate (2)	2	4	6	8	10
	High (3)	3	6	9	12	15
	Major (4)	4	8	12	16	20
	Catastrophic (5)	5	10	15	20	25

Figure 1 – Standard Consequence Likelihood Risk Matrix (based on AS 4360/ISO 31000)

Harvest strategies will therefore be designed to maintain an acceptable level of risk (i.e. medium or lower) for each of the objectives or, where the risk is currently high or severe, return the risk to an acceptable level (see Table 2).

For target species, the risk level will be determined using one of the five levels of quantitative stock assessment methods that are applied by the Department (see Table 4). It should be noted that stock assessments are really just specific forms of risk assessment (Francis & Shotton, 1997; Fletcher, 2015). The assessment of risk for other ecological categories (by-product, by-catch, habitat and ecosystems) and social and economic objectives will use the formal ISO 31000 based qualitative risk assessment process with the Consequence levels for each of the objectives relevant to the Policy as presented in Appendix 2.

This approach was first adapted for use in fisheries management by Fletcher *et al*. (2002) and Fletcher (2005) and further refined over the past decade for use in a wide range of fisheries situations where full details on its application are described (Fletcher, 2008; FAO, 2012; Fletcher & Bianchi, 2014; Fletcher, 2015).

Table 2. Risk Levels applied to all assets managed by the Dept. Fish. WA (modified from Fletcher, 2005).

Risk Category/Level	Description	Likely Reporting and Monitoring Requirements	Likely Management Action
1 **Negligible**	Acceptable; Not an issue	Brief Justification – no monitoring	Nil
2 **Low**	Acceptable; no specific control measures needed	Full Justification needed – periodic monitoring	None specific
3 **Medium**	Acceptable; with current risk control measures in place (no new management required)	Full Performance Report- regular monitoring	Specific management and/or monitoring required
4 **High**	Not desirable; continue strong management actions OR new and/or further risk control measures to be introduced in near future	Full Performance Report – regular monitoring	Increased management activities needed
5 **Severe**	Unacceptable; major changes required to management in immediate future	Recovery strategy and detailed monitoring	Increased management activities needed urgently

5.0 GUIDELINES FOR IMPLEMENTING THE POLICY

5.1 Setting Operational Objectives

To be consistent with the principles of ESD, the objects of the FRMA and more recent legislative and policy initiatives, the scope of issues that will be covered within harvest strategies for WA are broader than addressed in other jurisdictions. In addition to ensuring the biological sustainability of all captured aquatic resources, a harvest strategy may include relevant broader ecological, social and economic objectives. Importantly, however, to meet the objects of the Act, stock and ecosystem sustainability will always have priority.

Biological or ecological objectives will be developed at the resource level whereas social and economic objectives will most likely be generated at the sector or fishery level (Fletcher, et al, 2010; DoF, 2010). Furthermore, if there are competing economic and social objectives or sectoral allocation decisions their hierarchy/priority should be explicitly determined as part of the process of developing ARMS under the proposed ARMA (DoF, 2010). These decisions must be made prior to the development of the harvest strategy, not as part of this process.

5.2 Measuring Performance

5.2.1 Indicators

Choosing suitable operational objectives requires simultaneous identification of an appropriate indicator that reflects how the fishery is performing against this objective. An indicator can be a quantitative or qualitative measure of some attribute of the fishery that is:

- directly measured (e.g. % habitat area trawled);
- estimated using a model (e.g. biomass estimated using a stock assessment model), measured indirectly (e.g. surrogate/proxy measures of biomass such as changes in catch rates); or
- possibly inferred (e.g. changes in participation rates).

With the level of information and monitoring systems generally available in most fisheries, few objectives will be directly measured. Indirect or surrogate/proxy indicators will therefore be most commonly used to assess performance for most resources/fisheries.

Multiple Indicators for the one objective - More than one indicator (and their associated performance/reference levels) may be used to monitor performance of the same operational objective (e.g. both fishery-based and fishery-independent biomass estimates). This can provide greater confidence in situations where no single indicator is considered sufficiently accurate. This approach does, however, require the determination of how the indicators will be collectively interpreted to track performance in situations where they may show differing trends and a weight of evidence approach will be adopted (e.g. Wise et al. 2007, Fletcher, 2015).

5.2.2 Reference Values

To interpret the current or expected future value of an indicator in relation to the operational objective requires defining the levels that separate acceptable performance from unacceptable performance (Fig. 2). These performance or reference values are used to guide what management actions may be required and can include:

- a "target" (where you want the indicator to be),
- a threshold (where you review your position), or
- a limit (where you don't want the indicator to be).

Targets **–** Are the levels, ranges or directions of indicators that the fishery management system is aiming to reach, fluctuate within, or head towards respectively. They represent the desired state to best deliver the outcomes that meet the specific objectives of the fishery.

Thresholds **–** Define the level of the indicator beyond which performance is considered to be not desirable. It provides an 'early warning' in order to initiate a management review so that an appropriate (potentially predefined) level of response is generated to avoid having the indicator reach the limit level. The degree and speed of the management action resulting from this review should be consistent with the precision of the indicator/threshold settings that are being used, and how rapidly the limit level may be breached if insufficient actions are taken. The degree to which the action will be predefined will depend upon the degree of precision of the indicator in measuring performance against the objective (the more precise, the more predefined the action). Breaching the threshold could result in one or more of:

- the implementation of a review of current management,
- undertaking a planned rebuilding program by:

- implementing predefined adjustments to the fishing arrangements
- identification of suitable management actions designed to return the indicator to the desirable range,

- collection of additional information to reassess whether the threshold levels that are being used are sufficiently accurate and/or to reduce uncertainty in any of the parameter values that are used.

Limits – Defines the level below which the indicator would represent unacceptable performance and would require strong and immediate (predefined) actions to return the fishery/stock to a more acceptable level. Where the limits have been breached for a stock sustainability objective, serious consideration would need to be given to implementing a partial or complete closure of the fishery.

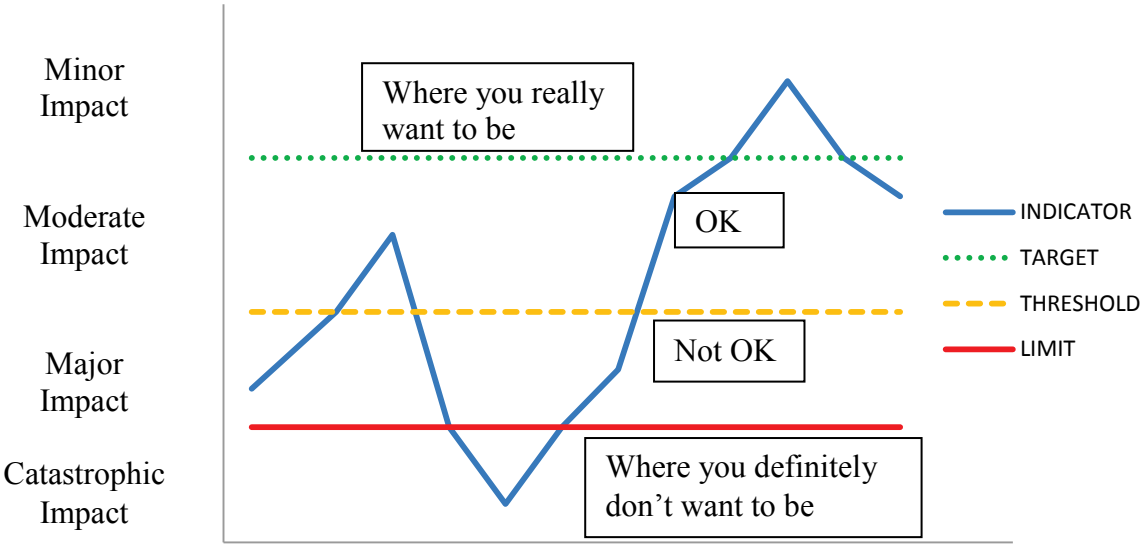


Figure 2. The general relationship between indicators, target, threshold and limit reference values and impact (consequence) levels. The x-axis represents time.

5.2.3 Incorporating Precision, Precaution and Risk in Performance Levels

Selecting the indicator and performance levels for each objective must be seen as a package. The precision of the indicators and performance levels used in the assessments should match the level of precaution used in the management settings. Where the inherent risks are low, imprecise indicators may be acceptable. Where the inherent risks are high, or the management approach is more 'aggressive', more robust and precise indicators and performance levels will be needed.

5.2.4 Incorporating uncertainty, timeframe and life history

To include uncertainty within a harvest strategy, it is important to realise that uncertainty has many different sources. This includes those associated with process, observation, model, estimation, implementation, and institutions (Francis and Shotton 1997).

- process uncertainty arises from the inherent natural variability in population dynamics;
- observation uncertainty arises in the process of data collection, through measurement and sampling error;

- model uncertainty arises from the lack of complete information on the population and dynamics of the system;
- estimation uncertainty arises from the process of parameter estimation;
- implementation uncertainty arises from the extent to which management policies will be successfully implemented; and
- institutional uncertainty arising from problems associated with the interaction of the individuals and groups (managers, scientist, economist, fishers, etc.) that compose the management process.

Including uncertainty within the harvest strategy should occur by selecting appropriately precautionary limit/thresholds levels or by setting appropriate precautionary probabilities of the indicators being above standard levels. The indicator and performance levels should be considered as a package and not be independently layered one on top of another to create unnecessary restrictions.

The type of life-history of a stock also affects how the harvest strategy should be constructed. Current best practice for multi-year class fisheries is to not only provide the 'current' estimate of status against a performance level for an objective but also provide an estimate (with a measure of uncertainty) of where it will be at some point in the future given the current or proposed management system to be applied and the likely (or known) recruitment levels. This risk analysis essentially asks "*what is the likelihood that given the current or proposed management arrangements, the fishery will meet its objectives sometime in the future*".

Thus, where practical and appropriate, assessing acceptable performance can include determining the probability/likelihood of being at or near the target level, or above the threshold and limit levels at some point in the future with a specified level of uncertainty. For example, the rock lobster stock sustainability objective requires the estimation of whether the egg production levels will still be above the threshold level both during and at the end of the next five years with at least 75% certainty (DoF 2012c).

Those fisheries that capture species with a single annual age class, the harvest strategy can only realistically focus on effectively managing what has recruited that year. It would then seek to ensure (to the extent possible) there is an acceptable level of egg production during that year.

Finally when designing the review processes for harvest strategies it is necessary to recognise that there are often inherent delays between a fishing activity and the provision, collation and analysis of data to produce catch summaries, stock assessment estimates and stock status advice for use in consultation, formulation and implementation of any new management arrangements. Each harvest strategy must explicitly incorporate the timeframes needed for these steps and decision making processes.

5.2.5 Categories of performance for different objectives and fisheries

Not every resource will require a harvest strategy that has all three reference levels or will be required to deliver all three types of objectives (ecological, social and economic). The only compulsory objective and performance reference levels will be those used to assess stock/ecological sustainability (Table 3). Specific performance levels and associated control rules will only be adopted for social and economic objectives where there is a practical

advantage and broad agreement from the relevant industry sectors. Having the appropriate data collection systems in place will also be necessary which is particularly important when considering specific objectives for recreational fisheries.

Table 3. Outline description of the unit of assessment (resource or fishery) that will be used to assess performance and which type of performance measures (limits, targets, thresholds) will be developed for the different types of objectives (stock, social, economic) plus which are mandatory and which will require sectoral and departmental support.

OBJECTIVE	**Stock/Ecological Sustainability Objectives (mandatory)**	**Social Objectives (requires sectoral support)**	**Economic Objectives (requires sectoral support)**
UNIT OF ASSESSMENT	**Resource**	**Fishery**	**Fishery**
Limit	Compulsory	Rare	Rare
Threshold	Compulsory (default is B_{msy} or equivalent)	Unlikely	Possible but unlikely
Target	Default is a value that is above B_{msy} or equivalent	Possible for some indigenous and recreational fisheries	Preferable for many commercial fisheries (e.g. MEY or proxy)

5.3 Stock Sustainability Reference Levels

The reference levels used for stock sustainability are designed to manage the impacts fishing can have on the future recruitment potential of a targeted resource. These are based on the principle of wanting to maintain spawning stock levels (spawning potential) above that where future recruitment should not be materially affected by the current stock size.

It is assumed that above these levels, the current environmental conditions should be the main drivers of recruitment variations. Therefore, all values that are 'above' these reference levels should be considered equally acceptable from the 'stock sustainability' perspective. While there may be other reasons (e.g. economic objectives) for wanting a higher level of stock, these are addressed separately.

The unit for the assessment for stock sustainability should be at the whole of resource level. Finer subsets may also be used where this is deemed more appropriate (e.g. sub-regions or zones).

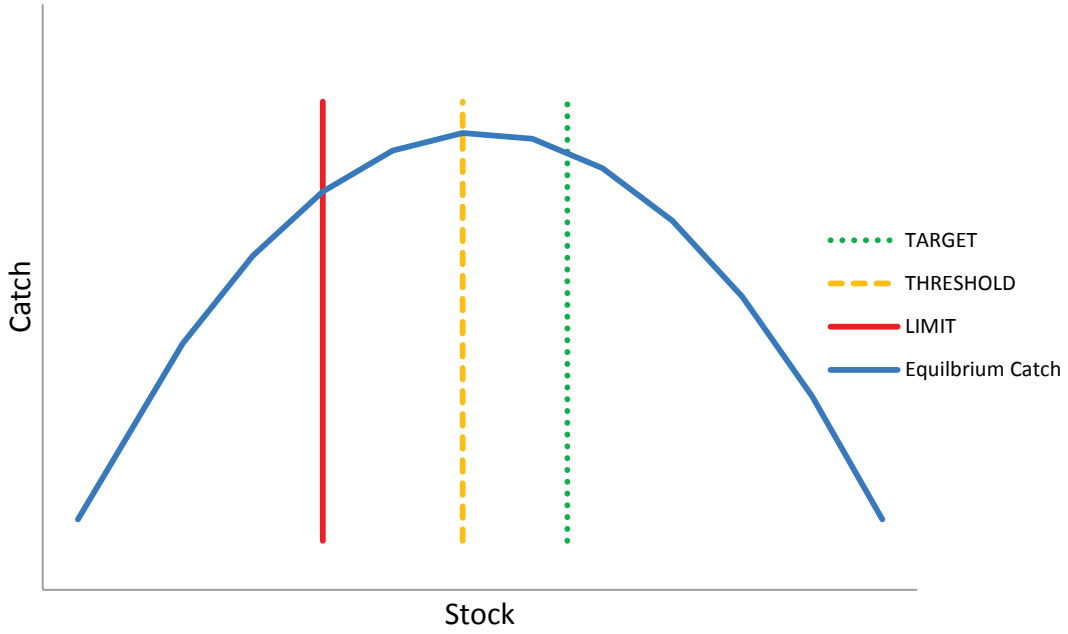


Figure 3. The equilibrium catch and relationship with the three stock related performance measures - threshold (at B_{MSY} or equivalent), target (somewhere above B_{MSY} or its equivalent), and limit (usually 0.5 B_{MSY} or its equivalent) levels. See text for more detailed descriptions of each of these levels.

5.3.1 Limit Reference Levels for Stock Sustainability

This is defined as being the stock level 'below'[7] which future recruitment levels arising from this stock is likely to be directly and adversely affected (i.e. recruitment overfished, or in MSC terminology - 'point of recruitment impairment'). This includes having their capacity to increase from a depleted state being diminished potentially leading to a stock collapse (Figures 3 and 4). The appropriate value for the limit level will vary between species and can be based on an empirical stock recruitment relationship for the species. Where this is not available, a theoretical level can be calculated using the relevant spawning potential/egg production at half of the maximum sustainable yield (MSY).

5.3.2 Threshold Reference Levels for Stock Sustainability

The long standing use of threshold reference levels within WA enables management actions to be initiated before a stock breaches the limit levels leading to recruitment overfishing. The threshold must be 'above' the level where there is considered to be a high likelihood of recruitment overfishing. If the indicator lies between the threshold level and the limit level this should still represent only a relatively low likelihood of recruitment overfishing actually occurring (Figures 3 and 4).

Current best practice in fisheries management assumes that where the stock is at a level that produces the maximum sustainable yield (MSY) should be used as the threshold reference level. If fishing mortality maintains the stock at or above these levels this would be highly unlikely to reduce the long term average spawning potential/egg production.

[7] Noting that for some indicators (e.g. when using *F*), the value may be 'above' the limit reference level

5.3.3 Target Reference Levels for Stock Sustainability

The MSC requires that a target level be established for each of the target/indicator stocks which must be at or above B_{msy} or equivalent. This will be used as the default position for those fisheries that are or will be undergoing MSC certification. More precise targets may be developed for some stocks based on economic or social considerations. These are discussed below (5.6).

5.4 Operationalising Threshold and Limit Levels

The specific reference levels will vary greatly among different species based on their individual biological and life history characteristics. Direct measurement of spawning potential or total egg production is not common with other more practical alternatives such as spawning stock biomass often used. The default threshold and limit levels for the different categories of species/stocks and surrogates/proxies currently used for managing stock sustainability in Western Australia are presented in Wise et al., (2007) and DoF (2011). These were chosen based on international and local studies and include an appropriate level of precaution. Moreover, the specific performance levels that are selected for each of the stock and ecological objectives must now also be consistent with meeting the requirements of the MSC guidelines.

5.4.1 Multispecies fisheries and Species Suites

To accommodate the numerous multispecies finfish fisheries managed in WA, the approach that has been adopted by the Department is to use one or more indicator species to monitor the status of the entire suite of species (Wise et al., 2007; DoF 2011). This policy approach has been used to successfully develop the management arrangements for a number of multispecies finfish fisheries where the fishing operations and their management arrangements generally affect the entire suite rather than individual species. This approach has been applied to the Northern Demersal Scalefish Fishery, the Pilbara Demersal Trawl/trap and Line fisheries, the West Coast Demersal Scalefish Fishery.

A feature of this approach is that even if only one of the indicator species has breached the threshold or limit level, then the entire suite of species is deemed to have breached this level. This would require appropriate management arrangements to be implemented to adjust overall levels of effort. This is considered the most efficient method for dealing with these types of fisheries because it reduces the number of detailed assessments that need to be undertaken. Furthermore because the management response of lowering the overall effort on the suite to reduce the fishing mortality on the stock that is at unacceptable levels, it is also a precautionary approach because it minimises the opportunity that discard mortalities will affect recovery as may occur if a separate quota based management of the species was used.

5.4.2 Straddling and Migratory Stocks

The Department does not have jurisdiction for fisheries targeting large-scale straddling or migratory stocks (e.g. tuna). Under the Offshore Constitutional Settlement (DoF, 1996) these are managed by the Commonwealth, although there are two ‘shark’ fisheries that the Department manages under a Joint Authority jurisdiction with the Commonwealth that share stocks to varying degrees with the adjacent jurisdictions. A few species (e.g. Australian Herring and Australian Salmon) are managed under Western Australian jurisdiction but are shared with an adjacent jurisdiction, while some stocks under Western Australian jurisdiction straddle different managed fisheries. In all cases the aim of any Harvest Strategy is to ensure that the take in the other fishery or jurisdiction is recognised in the setting of catch or effort

levels. In the case of the few stocks straddling jurisdictions, joint Harvest Strategies for the resource may need to be developed.

5.4.3 Recovery Phase Performance Reference Levels

Stocks that are currently below acceptable levels but for which suitable management adjustments have already been imposed to reduce their catch and/or effort to appropriate levels (as outlined in their set of Harvest Control Rules), are considered to be in a recovery phase. Within this recovery phase, the normal performance levels will often not be sufficient and, consistent with MSC requirements; a recovery plan should be developed.

Applying the 'normal' performance levels and Harvest Control Rules a second (or more) time to a stock that is already considered to be in a 'recovery phase' but for which there has not been time to recover would not be appropriate. The indicators may still be below the threshold/limit reference level despite the additional management actions. Instead, the recovery plan for the stock should establish what are the explicit short-term performance levels that would represent an appropriate rate of recovery consistent with the vulnerability and productivity of the species involved plus the dynamics of the fishery. These 'recovery performance levels' should be agreed before the recovery-based management arrangements are implemented to reduce dispute among stakeholders about whether recovery is 'working' when the next review is undertaken. Appropriate recovery could be defined by the indicator reaching an agreed intermediate level or the acceptable level within a certain time and level of certainty.

Another consideration when developing recovery plans includes the current environmental conditions. This is especially so where these conditions have led, or contributed significantly, to the resource being at an unacceptable level. It must be recognised that if the environment is still unfavourable, this will impact on the likely speed and extent of stock recovery.

5.5 Ecological Sustainability Reference Levels

In situations where a particular resource plays a specific and crucial role in ecosystem functioning for which there is low redundancy (i.e. no other species or group plays this specific and important role; see Power, et al., 1996), this may require the establishment of reference level to ensure broader ecological sustainability. This could require having a lower harvest rate based on their ecosystem role compared that which would otherwise be recommended based solely on their individual biological characteristics (e.g. forage fish such as sardines). In such situations it may be necessary to develop threshold and limit levels for stock abundance that are adjusted to more precautionary levels (e.g. this has already been factored into the management approach used for WAs sardine fisheries) than would be set purely on an individual stock recruitment basis. This is equivalent to the low trophic level criteria used within Marine Stewardship Council assessments.

5.6 Economic and Social Reference Levels

5.6.1 Target Levels

5.6.1.1 Commercial fisheries

For stocks/suites that are solely or largely fished by a single commercial fishery (e.g. lobsters, deep sea crabs), a target level or target range of stock abundance (**that is above the stock**

sustainability threshold level i.e. above B_{MSY}) that industry considers would assist generate more optimal levels of economic efficiency could be established (Figure 3).

Economic efficiency is not only affected by relative stock abundance it can also be affected by how and when the industry is able to access the resource. Hence the control rules may not only be associated with maintaining a specific level of stock but how the industry is able to access the stock.

Defining an economic efficiency target level, range or direction can be made using a number of different methods. The following outline some of the many methods including but not limited to:

- Selecting an abundance or catch level that generates the catch, catch rates, marketable sizes, etc. that industry considers most appropriate;
- Selecting an abundance level based on a 'rule of thumb' that the abundance for MEY is generally 20% or more above the level for MSY[8];
- Formally calculating the MEY level of abundance using quantitative economic and other related data for the specific fishery; or
- Completing a survey of fishers/industry/processors of what they consider is the best catch rate, size range of the catch, or overall catch level etc.
- Level of industry submissions/communications related to their concerns about management arrangements affecting their economic efficiency

Developing agreed target levels may be difficult where there is more than one commercial fishery (or multiple zones) targeting the same stock or if the recreational component takes a significant proportion of the stock (>30%).

Consideration of any unwanted effects on social outcomes, broader community concerns and overall return to the community may be needed if adoption of an MEY strategy involves significant reductions in catch levels, shifts in fishing methods or other practices.

5.6.1.2 Recreational fisheries

For stocks/suites that are only (or largely) fished recreationally (e.g. marron) it is expected that the appropriate target level could be one that generates the best social amenity outcome for the majority of participants. This may not always be the same for all fisheries or even in all areas as it could relate to total catch, catch rates, sizes of fish caught, distribution of catch among participants, certainty of capture, location of capture, etc. Some level of data collection relevant to the chosen objective would be needed but these may need to be qualitatively measured.

Determining the best social outcome would have to be done in strong consultation with the recreational sector bodies and would be affected by whether the species/suite targeted by the sector are:

- Trophy/Iconic species - this could require settings to ensure catch rates or sizes of individual fish caught maximise enjoyment rather than maximise total catch.
- For the 'bread and butter' species this could require settings to be similar to deliver MSY as this would maximise the quantity that could be captured and how to share the catch.

[8] Kompas and Grafton (2011) Target and Path: Maximum Economic Yield in Fisheries Management. ABARES technical report 11.3, Canberra

5.6.1.3 Mixed sector fisheries for a single resource (Implementing IFM)

Where a resource is captured by more than one stakeholder group (including more than one commercial sector, e.g. demersal scalefish), the economic and social objectives for each of these can often differ (e.g. larger sizes versus higher quantities versus high catch rates). This will often make the establishment of a target reference level very difficult and it is possible that this could involve a compromise in setting an overall target reference level that provides the best overall community outcome, optimising among the differing requirements. Alternatively, spatial zoning could be used to deliver different types of outcomes in different areas. The process for determining the allocation decisions and any priority for objectives should occur during development of the ARMS or from the IFM process. Once these decisions are made, the harvest strategy for the resource can then be developed to reflect the outcomes of these decisions with the control rules for each sector designed to deliver the particular objective and any associated allocation decisions. To reiterate, it is not expected or appropriate to use the harvest strategy development process to make these decisions, only deliver them.

5.7 Monitoring and assessment procedures

5.7.1 Target Stocks

The specific methods used for monitoring and assessment are affected by many factors including the level of risk, biology and population dynamics; the type, size and value of the fishery; data availability and historical level of monitoring. The methods used vary from relatively simple analysis of catch levels and catch rates, through to directly sampling the catch (fishing mortality), fishery independent surveys up to highly complex and expensive simulation modelling.

In all cases a "weight of evidence approach" (WoE) is adopted in WA that examines the different available lines of evidence in combination with the biological characteristics of the species to determine current status (Wise et al., 2007; Fletcher, 2015). The range of quantitative methods used by the Department have been divided into five broad categories for the past decade:

Table 4 - Different Assessment levels used in WA (see DoF, 2012b for more details)

Assessment Level	Description
Level 1	Catch data only
Level 2	Level 1 plus fishery-dependent effort
Level 3	Levels 1 and/or 2 plus fishery-dependent biological sampling of landed catch (e.g. average size; fishing mortality, etc. estimated from representative samples)
Level 4	Levels 1, 2 or 3 plus either fishery-independent surveys of relative abundance, exploitation rate, recruitment; or standardised fishery-dependent relative abundance data
Level 5	Levels 1 to 3 and/or 4 integrated within a simulation, stock assessment model.

5.7.2 Other Ecological Resources

The monitoring of the other ecological resources including bycatch, TEPS, habitats and ecosystems are completed using a variety of methods. These include information recorded by

fishers in logbooks, on-board observer monitoring, VMS, and direct surveys within and outside of fished areas. The frequency and intensity of this monitoring should be commensurate with the level of risk and the dynamics of the fishery and the species involved.

5.8 Harvesting Approaches

Several alternative harvesting approaches are used in WA (Figure 3). These are designed to accommodate the different characteristics of individual fish stocks and fisheries. They include:

- **constant harvest or exploitation** - where the same proportion of the available stock is taken each year. The annual catch rises and falls in proportional to variations in stock abundance (e.g. abalone, pre 2008 western rock lobster, pearl oysters).,

- **constant escapement/stock size** - where the catch is adjusted annually to ensure a certain minimum proportion of the stock always remains at the end of each season (e.g. Exmouth Gulf tiger prawn, Shark Bay Scallops) or is expected be present sometime in the future (e.g. post 2008 western rock lobster, Shark Bay Snapper).

- **constant catch** – the annual catch level is relatively small compared to stock levels and therefore unaffected by normal levels of recruitment variation (e.g. south coast pilchards).

Most fish stocks in WA are exploited under a constant harvest or exploitation level with some stocks managed on the basis of constant escapement and a few fisheries managed by taking a constant catch. Once the most appropriate harvest approach has been identified and adopted, the most suitable management arrangements such as quotas, seasons, spatial limits, and gear restrictions can be determined and implemented.

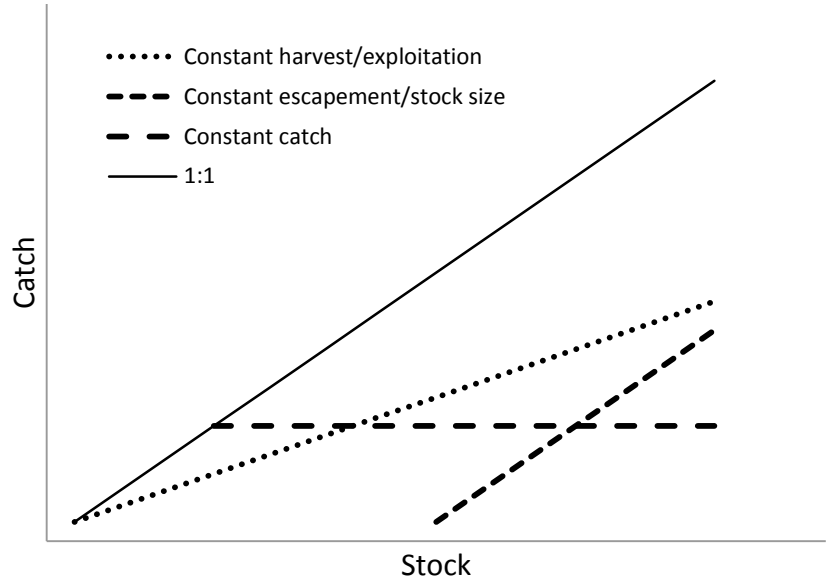


Figure 4. Simplified representations of the harvesting strategies of constant harvest/exploitation, constant escapement/stock size and constant catch (Hilborn and Walters, 1992).

5.9 Harvest Control Rules

The Harvest Control Rules (HCRs) define what management actions should occur to meet the agreed objectives for the resource based on the current or likely future levels in relation to (where relevant) the limit, threshold or target levels plus any IFM based, allocation decisions. These control rules therefore define what is the appropriate level of catch and or effort for the fishery/sector given the current state of the stock (Fig. 5) and, where relevant, their sectoral allocations.

The basic concept used for determining the control rules for a resource/fishery is that a higher level of fishing mortality (which is usually translated into allowing higher levels of catch and/or effort) can be tolerated when the stock is high (i.e. at or above the target level). As the stock decreases, Fishing Mortality (*F*) must also decrease which is usually translated by the control rules into allowing a lower level of catch and/or effort. The closer the stock is to the limit level the greater is the level of reduction (Fig. 5).

The less precise and/or accurate the indicators are in measuring performance against the objective, the less prescriptive can the actions be within the Harvest Control Rules. There will, therefore, be few cases where the indicators and the various performance measures are known with sufficient precision and accuracy to enable highly prescriptive control rule adjustments to catch and or effort. Where, for example, catch level is being used as the indicator of stock abundance, a number of factors other than stock abundance can affect these levels (such as fuel and market price etc. that can affect fishing patterns). The minimum action required for a control rule is if a threshold level is reached, a review of the situation must be undertaken.

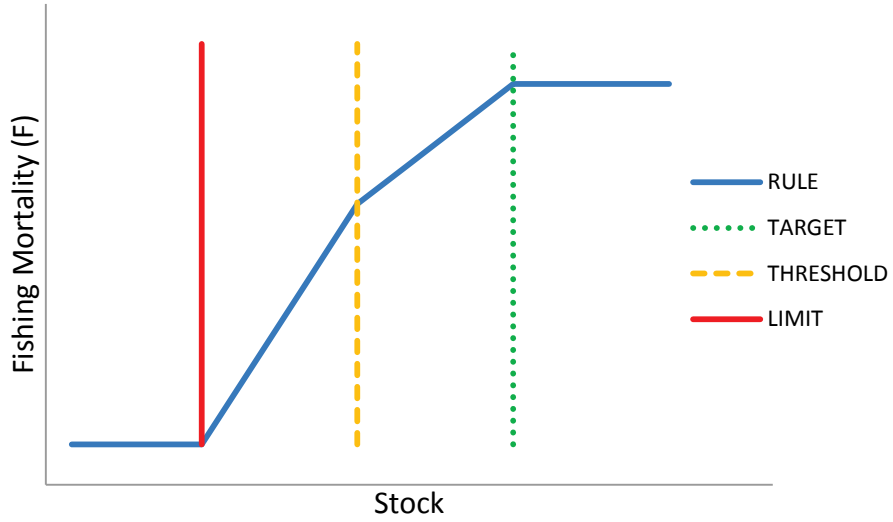


Figure 5. The general relationship between the expected changes to fishing mortality used for harvest control rules based on current stock in relation to target, threshold and limit reference values.

5.10 Stock/Resource Status Terminology

The terminology used to describe stock status and fishery status varies greatly amongst national and international jurisdictions. The terminology adopted for WA has been designed to conform to standard risk management approaches because the primary goal of the management actions developed for each fishery is to achieve the objectives that relate to

whether a stock is currently *adequate, inadequate, recovering or environmentally limited*. These terms reflect that a resource/stock can be at an inadequate level for reasons other than over-harvesting including external impacts, e.g. estuarine health, environment conditions. Use of terms such as 'overfished' can, therefore, often be inappropriate.

> *Adequate*: The indicator(s) reflects that the stock status is (are) above the threshold level(s).
>
> *Inadequate*: The indicator(s) reflects that the stock status is (are) below the threshold or limit level(s) and a recovery plan has not yet been implemented or the management actions are not yet confirmed as operating effectively to reasonably assume that they are generating a sufficient rate of recovery. This outcome includes situations where excessive fishing pressure (catch), some external event, or a combination has led to the breeding stock biomass falling to levels where there is now a high risk of future recruitment levels being measurably reduced. This is equivalent to MSC's point of recruitment impairment.
>
> *Environmentally Limited*: This indicates situations where the stock is at unacceptable levels due primarily to environmentally driven impacts, not from fishing activities.
>
> *Recovering (rebuilding)*: This reflects situations where the indicator is still below the threshold or limit level but an appropriate recovery plan has been implemented. There is either evidence recovery is now occurring at an acceptable rate due to these additional management actions and/or natural processes, or there is a reasonable expectation this will occur.

Each identified resource will be assessed at appropriate intervals with some level of assessment undertaken annually. For many longer lived species detailed assessments (e.g. Levels > 3) will generally be completed at time intervals of 2 - 5 years with simpler assessments (Levels 1 or 2) completed within the intervening years (DOF, 2012d).

For the purposes of reporting to the WA Parliament, the term 'sustainable' has been defined as those resources where the breeding stocks are considered adequate or those where the breeding stocks are considered to be recovering.

5.11 Allowable Catch/Effort/Catch Rate Tolerances

The Harvest Control Rules define the appropriate annual 'harvest levels' either in terms of the specific catch or effort levels for each fishery that should be 'taken' given the current status of the stock(s) in relation to the various performance levels. In addition to these stock sustainability based requirements, a growing number of fisheries have sectoral catch allocations that they must also achieve.

Given the highly dynamic and interactive nature of fisheries it is often not possible to predict precisely what catch will be generated each year especially when using effort limits and other associated management arrangements applied for effort controlled fisheries. Even for output controlled fisheries, the full quota may not always be taken each year and there will be variations in the level of effort needed to take the quota. Some level of tolerance is therefore required to ensure that unnecessary management interventions are minimised and there is greater certainty about what levels of discrepancy in catch and/or effort are allowed before explicit adjustments to the management arrangements of a fishery will need to be made.

By determining an explicit allowable catch, effort or catch rate tolerance for each fishery provides the mechanism to more consistently and efficiently determine whether the specified 'harvest levels' from the HCRs and sectoral allocations from IFM are being successfully achieved by the current management arrangements. This provides industry greater certainty about when changes to management arrangements will be implemented. Whether an acceptable catch and or effort range is used will depend upon the types of management arrangements used:

- output based (e.g. catch quotas TACs)
- input based (e.g. effort managed, TAEs) or
- some combination of output/input.

5.11.1 Output Based - Catch Quota-Managed Fisheries

Output based fisheries require specific acceptable catch and effort ranges that specify the proportion of the Total Allowable Catch (TAC) expected to be taken and an appropriate range of fishing effort that should be used to take this.

For fisheries managed by TACs, the success of the management arrangements includes whether the majority of the Total Allowable Catch (TAC) has been achieved but only by using an anticipated amount of fishing effort. Therefore if an *unusually large expenditure of effort* has been needed to take the TAC, and/or if sector fails to achieve the TAC by a *significant margin*, and this cannot be easily explained by some shift in markets, costs or other non-stock related external factor a review is required. Where either or both of these situations occur, this may indicate that the abundance of the stock is significantly lower than what was estimated.

Developing the allowable tolerance levels for each quota fishery involves specifying what is considered a '*significant margin'* or an *unusually large expenditure of effort* for that fishery.

5.11.2 Input based - Effort Managed Fisheries

The majority of commercial and recreational fisheries in WA have **'**effort based' management systems. These seek to directly control the amount of effective fishing effort applied to stocks to generate a catch close to the level defined by the harvest control rules and, where relevant, sectoral allocations.

An agreed level of tolerance around these catch levels is required to establish acceptable catch ranges for each fishery that define what levels of catch will be considered consistent with the desired harvest level that meets both the HCR (stock sustainability) and IFM (sectoral allocation) requirements. The tolerance level therefore defines what point above or below the specific catch level should no longer be considered acceptable and potentially require adjustments to the effort (or other factors).

The degree of tolerance allowed for a fishery should reflect the level of uncertainty, the current level of risk to the stock, the degree of difficulty in changing management settings and the likelihood of any external cause of the variation (e.g. economical or environmental conditions). The process for adjusting effort may be relatively simple for most ITE based fisheries, but it can be more complicated for those fisheries where input controls are not unitised or there is significant latent effort.

5.11.3 Allocation and Cross Sectoral Issues

For resources that are harvested by a number of separate fisheries (commercial, recreational, indigenous) the assessment of the effectiveness of the harvest control rules may need to occur at a number of levels (e.g. WCDSF). There will generally be an acceptable catch range based on the total cumulative catch, but additional acceptable ranges may also be needed for each sector (commercial – recreational) and in some cases each fishery (e.g. charter, wetline, gillnet, etc). Furthermore, clarification may be needed for whether the comparisons for allocations will be based on catches for individual species, the main suite, or the entire regional catch (multiple suites).

Consequently, the acceptable catch ranges can either be developed at the individual fishery or sector level and may involve the use of multi-year averages of the catch to enable minor "unders and overs" to occur to reduce the need for continuous (but unnecessary) management adjustments and interventions (DoF, 2012d).

5.12 Fishery Status Terminology

The success of the current management arrangements in delivering the required harvest levels to meet HCR and IFM requirements for each fishery will be assessed annually for commercial fisheries and at regular intervals for recreational fisheries. If the annual catch and effort remains within the acceptable range, there should be no need to adjust the management settings. Where the annual catch or effort for a fishery falls outside of this range and this cannot be adequately explained (e.g. environmental or market induced impacts), either management adjustments or a review to assess the underlying cause (from which management adjustments will often occur) will be required.

Acceptable Performance – Where the annual catch, effort or catch rate is within the Acceptable Catch/Effort tolerance levels for the fishery, or there is an appropriate reason for this not to have occurred.

Unacceptable Performance – Where the annual catch, effort or catch rate is not within the Acceptable Catch/Effort tolerance levels for the fishery and there is no known appropriate reason for this to have occurred.

5.13 Harvest Strategy Assessment Review and Decision Making Process

The decision making processes used in reviews of management arrangements to deliver a harvest strategy can be summarised by two decision trees (see Figures 6 and 7). The steps involved in determining whether or not the existing management arrangements are delivering acceptable resource outcomes are outlined in Figure 6 whereas Figure 7 outlines how annual fishery performance will be assessed.

These processes are already being completed annually to provide the information to generate the Key Performance Indicators for the Department's Annual Report to Parliament on the Government's desired outcome which is '*the conservation and sustainable development of the State's fish resources.* This is measured as:

- The proportion of fish stocks identified as being at risk or vulnerable through exploitation
- The proportion of commercial fisheries where acceptable catches (or effort levels) are achieved
- The proportion of recreational fisheries where catches or effort levels are acceptable.

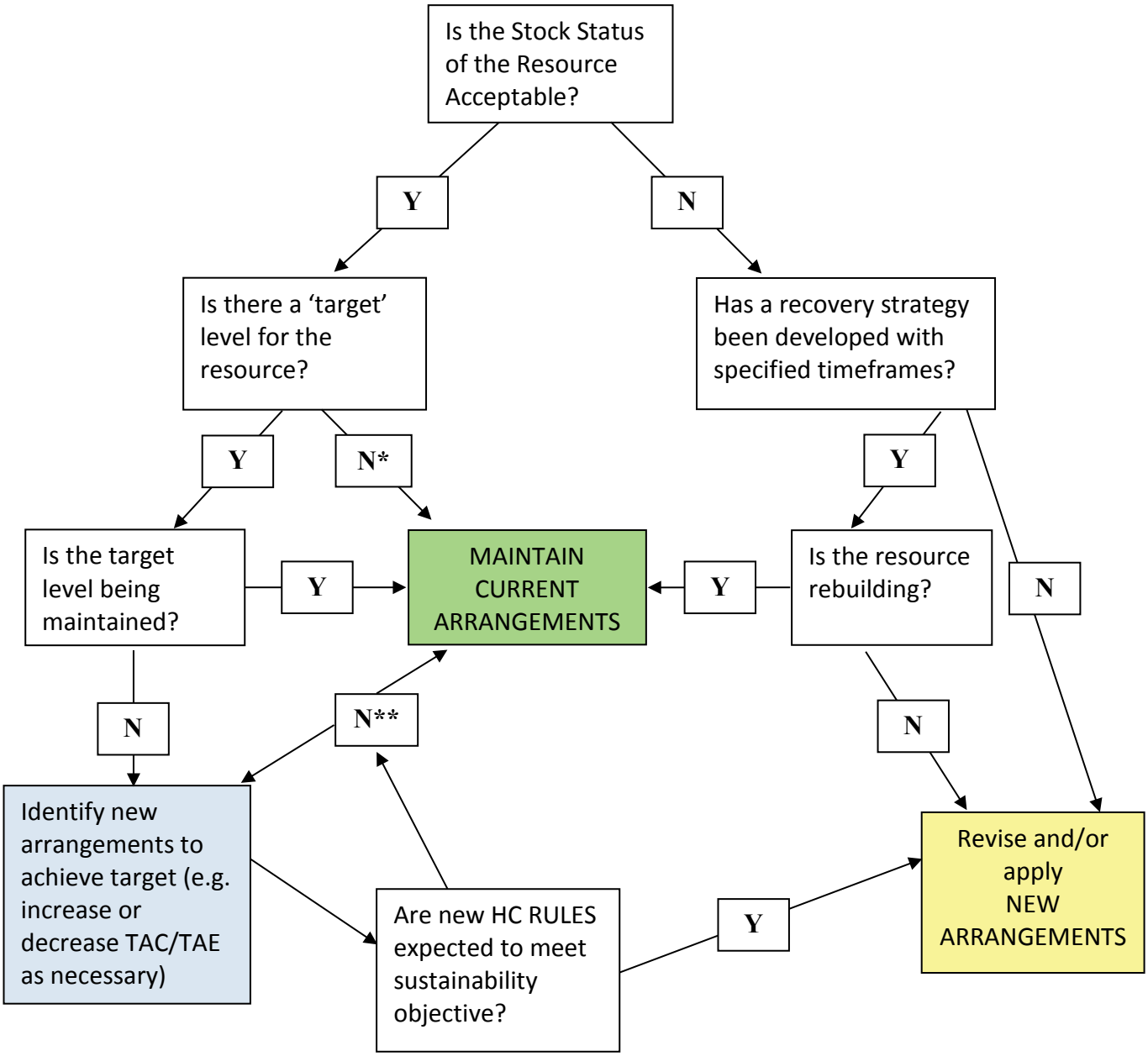


Figure 6. Decision tree for regular review of stock status for resource sustainability.

"New Arrangements" can include any activity associated with management process.
* Not all operational objectives have target levels.
**The primary sustainability objective must be met.

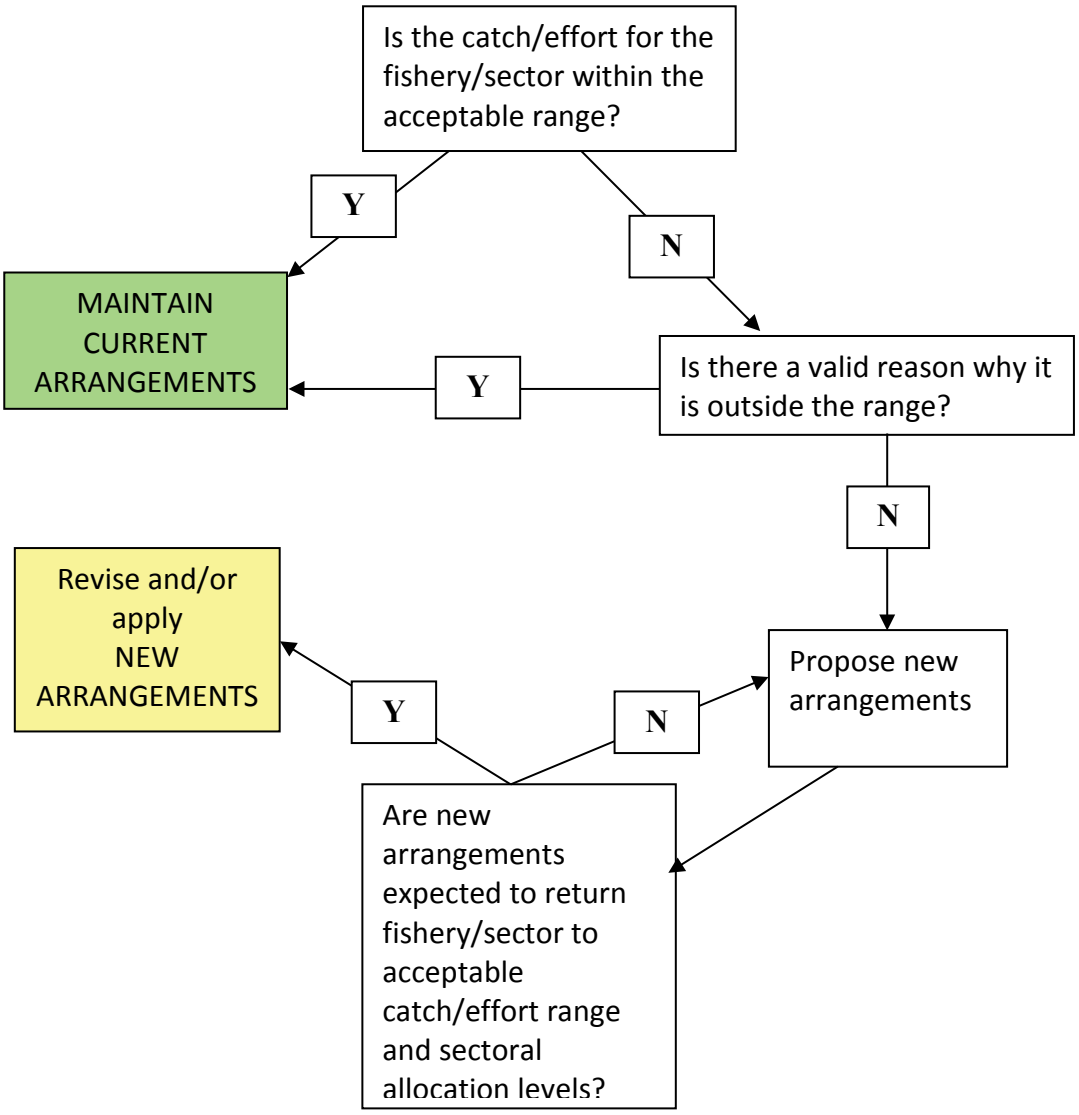


Figure 7. Decision tree for regular assessment of fishery performance and sectoral allocations.

5.13.1 Examples

Several fisheries have already had harvest strategies developed based on the principles outlined in this policy.

The examples that are available include:

1. The Western Rock lobster fishery is an output (quota) based, single species fishery. The stock is managed using a 'constant stock size'[9] harvesting approach that, as a minimum, maintains egg production above threshold levels for next five years to establish the annual acceptable catch level but an additional economic objective is used to determine the final commercial quota. There is a formal allocation of 5% of the acceptable annual catch to the recreational sector and management arrangements to ensure the sector is managed to this catch level.
2. The Shark Bay and Exmouth Gulf Prawn trawl fisheries are effort based, multi-species commercial fisheries that use a 'constant escapement'[9] harvesting approach (maintain spawning stock above a minimum level each year) with economic elements determining the in-season management arrangements for opening and closing sections of the fishery. There is negligible recreational catch of these species.
3. The West Coast Demersal Scalefish Fishery is a multi-species, multi-sector multi-gear fishery that is based on a 'constant exploitation'[9] approach (i.e. maintain *F* at appropriate levels in each zone) using input controls (effort units on a zonal basis) for the commercial sector and a combination of bag/size and boat limits plus time and area closures for the recreational sector. This fishery has formal sectoral allocations of catch both among and within sectors that must also be maintained.

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[9] See section on Harvesting Approaches and the glossary for more detailed explanation

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8.0 APPENDICIES

8.1 Appendix 1. Comparison of the structure and terminology used by the WA Harvest Strategy Policy (the Policy).

Table A1 – Comparison of the Policy with the national harvest strategy guidelines (HSG; Sloane et al., 2014), the Marine Stewardship Council guidelines (MSC, 2013) and the Commonwealth's EPBC Guidelines for Sustainable Fisheries (CoA, 2007b).

National HSG	MSC	EPBC	WA HS Policy
Defined operational objectives for the fishery	Short and long term objectives are explicit within the fishery's management system. The management system provides for incentives.	Management policies must be strategic, containing objectives and	Articulation of operational objectives for resource
Indicators of fishery performance related to the objectives		… performance criteria by which the effectiveness of the management arrangements are measured	Determine indicators to measure performance against each operational objective
A statement defining acceptable levels of risk for the fishery Reference points for performance indicators;	Management objectives are reflected in the target and limit reference points.	There are reference points (target and/or limit), that trigger management actions including a biological bottom line and/or a catch or effort upper limit beyond which the stock should not be taken.	Based on achieving acceptable risk levels, establish appropriate reference points/levels for each performance indicator
		There are management strategies in place capable of controlling the level of take	Select the most appropriate Harvesting Approach – (e.g. constant harvest/exploitation, constant escapement/ stock size).
Decision rules that control the intensity of fishing activity.	Well defined harvest control rules are in place that are consistent with the harvest strategy and ensure that the	Be capable of controlling the level of harvest in the fishery using input and/or output controls	Select Harvest Control Rules – pre-defined actions based on current status designed to adjust fishing intensity

National HSG	MSC	EPBC	WA HS Policy
	exploitation rate is reduced as limit reference points are approached		(catch/effort) to either maintain target levels and avoid breaching thresholds/limits or return to acceptable levels in an appropriate timeframe
	Available evidence indicates that the tools in use are appropriate and effective in achieving the exploitation levels required under the harvest control rules.		Establish the Acceptable Catch/Effort tolerance levels to consistently determine whether the specified 'harvest levels' to meet HCRs and IFM allocations are being successfully achieved by the current management arrangements.
A monitoring strategy to collect relevant data to assess fishery performance; A process for conducting assessment of fishery performance relative to objectives	Stock abundance and fishery removals are regularly monitored at a level of accuracy and coverage consistent with the harvest control rule The assessment is appropriate for the stock and for the harvest control rule.	There is a reliable information collection system in place appropriate to the scale of the fishery There is a robust assessment of the dynamics and status of the species/fishery and periodic review of the process and the data collected.	Monitoring and assessment procedures - collection and analysis of all the data needed to underpin the harvest strategy and determine stock status and fishery performance against operational objectives
	The harvest strategy is periodically reviewed and improved as necessary	Provide for the periodic review of the performance of the fishery management arrangements and the management strategies, objectives and criteria	The timetable and frequency for Review

8.2 Appendix 2. Risk Assessment Categories and Levels

LIKELIHOOD LEVELS

1. Remote - Never heard of but not impossible here. (<5% probability)
2. Unlikely - May occur here, but only in exceptional circumstances. (>5%)
3. Possible - Clear evidence to suggest this is possible in this situation. (>30%)
4. Likely - It is likely, but not certain, to occur here. (>50%)
5. Certain - It is almost certain to occur here (>90%)

CONSEQUENCE LEVELS

Note if not measurable Consequence level is essentially 0.

FISH STOCKS (target and non-target) – measured at stock level

1. Measurable but minor levels of depletion to fish stocks.
2. Maximum acceptable level of depletion of stock.
3. Level of depletion unacceptable but still not affecting recruitment levels of stock
4. Level of depletion of fish stocks are already (or will definitely) affect future recruitment potential/levels of stock.
5. Permanent or widespread and long term depletion of key fish stocks, close to extinction levels.

HABITATS – measured at regional level

1. Measurable impacts to habitats but still not considered to impact on habitat dynamics or system.
2. Maximum acceptable level of impact to habitat with no long term impacts on region wide habitat dynamics.
3. Above acceptable level of loss/impact with region wide dynamics or related systems may begin to be impacted.
4. Level of habitat loss clearly generating region wide effects on dynamics and related systems.
5. Total region wide loss of habitat and associated systems.

ECOSYSTEMS – measured at regional or IMCRA meso scale level

1. Measurable but minor change in the environment or ecosystem structure but no measurable change to function.
2. Maximum acceptable level of change in the environment/ecosytem structure with no material change in function.
3. Ecosystem function altered to an unacceptable level with some function or major components now missing &/or new species are prevalent.
4. Long term, significant impact with an extreme change to both ecosystem structure and function. Different dynamics now occur with different species/groups now the major targets of capture or surveys.
5. Permanent or widespread long term damage to the environment. Total collapse or complete shift of ecosystem processes.

PROTECTED/THREATENED SPECIES – measured at stock or regional level

1. The level of capture is common but will not further impact on stock and well below that which will generate public concern.
2. Level of capture is the maximum that will not impact on recovery or cause unacceptable public concern.
3. Recovery may be being affected &/or some clear but short term public concern will be generated.
4. Recovery of times are clearly being impacted &/or pubic concern is widespread (refer R&I).
5. Further declines in threatened stocks are occurring or major public concern is ongoing (refer R&I).

ECONOMIC (Commercial) IMPACT – measured at regional or entire fishery level

1. A small measurable but temporary impact on economic sustainability of some fishers in relevant fisheries.
2. A minor ongoing impact on economic sustainability of all/most fishers in relevant fisheries.
3. Temporary significant impact on economic sustainability, or ongoing moderate impact on economic performance for industry.
4. Long term major reductions in economic sustainability for relevant fisheries and their related industries.
5. Permanent and widespread complete cessation of economic sustainability for the fisheries and their related industries.

SOCIAL (recreational) IMPACT – measured at regional level

1. Temporary and minor additional stakeholder restrictions or expectations (< 1 year).
2. Some minor ongoing restrictions or loss of expectations.
3. Some important expectations suspended or severely restricted in the medium term (> 2 year).
4. Long term suspension or restriction of expectations in some key recreational activities.
5. Permanent loss of all key expectations for recreational activities on this asset.

COMMUNITY (Social Structures) IMPACT – measured at local and regional level

1. Some minor impacts may be measurable but minimal concerns.
2. Clear impacts but no local communities threatened or social dislocations.
3. Major impacts at least at local level, disruptions now evident.
4. Impacts occurring at broader level or severe local impacts.
5. Complete alteration to social structures across a region.