# A GUIDELINE TO THE HARVEST STRATEGY APPROACH FOR SUSTAINABLE FISHING

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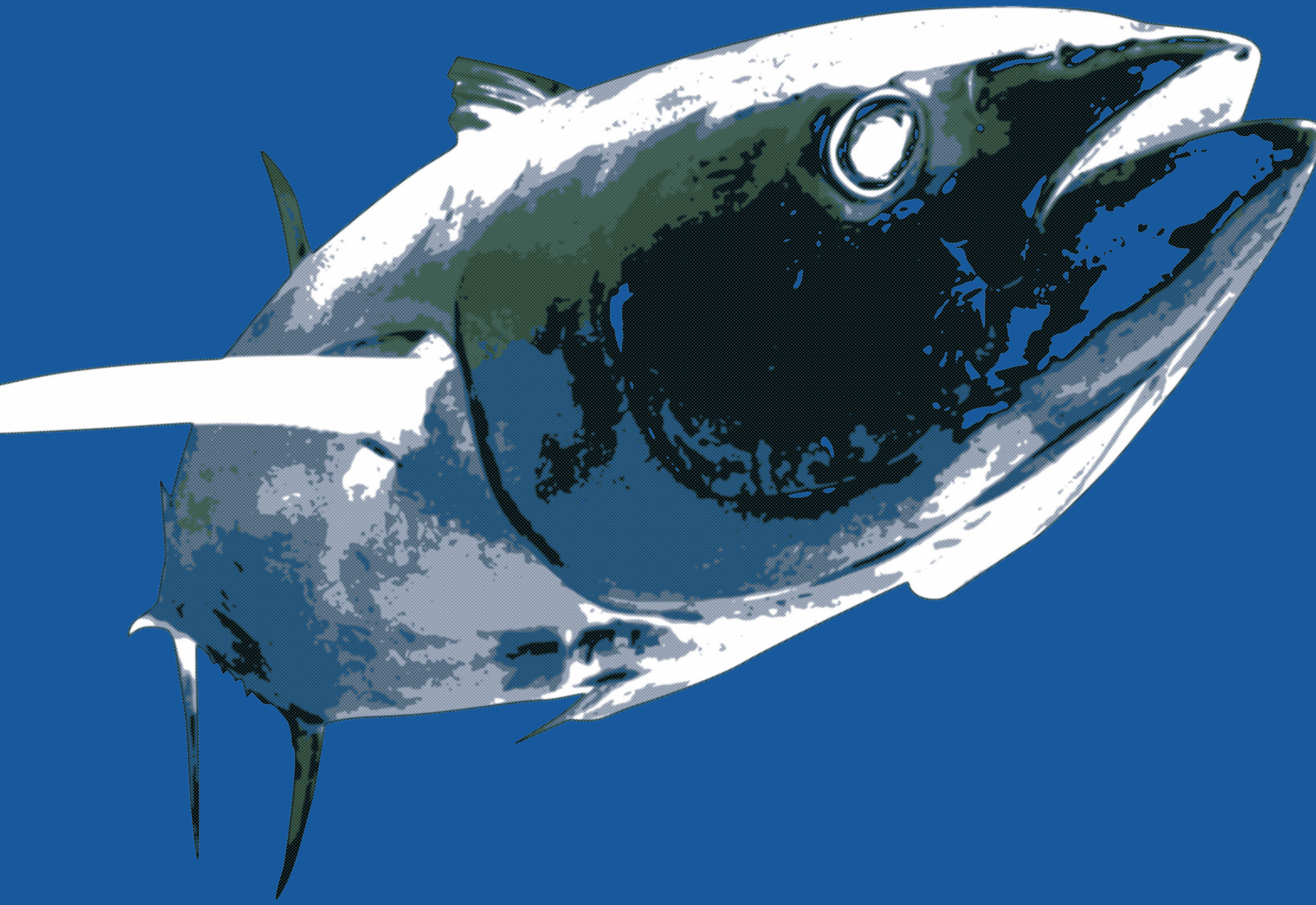
# TUNA TODAY TOMORROW



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# HARVEST STRATEGY: CREATING A MANUAL FOR MANAGEMENT SUCCESS

A Harvest Strategy represents the basic guidelines that describe how managers go about setting general harvest levels or allowable fishing levels. Generally, a Harvest Strategy outlines the management actions necessary to achieve defined biological and economic objectives in a given fishery. Thus, the choice of Harvest Strategy affects the yield from the fishery and the risk of overfishing.

## A HARVEST STRATEGY CONTAINS THE FOLLOWING ELEMENTS:

- Limit Reference Points: Don't GO THERE!
- Target Reference Points: Aiming for the right level
- Uncertainty: Accounting for what we don't know
- Risk: Determining Acceptable Loss
- Harvest Control Rules: Streamlining Fisheries Decision Making and Sustainability
- Management Strategy Evaluation: Will the Harvest Strategy Work or, Later, Is it Working?

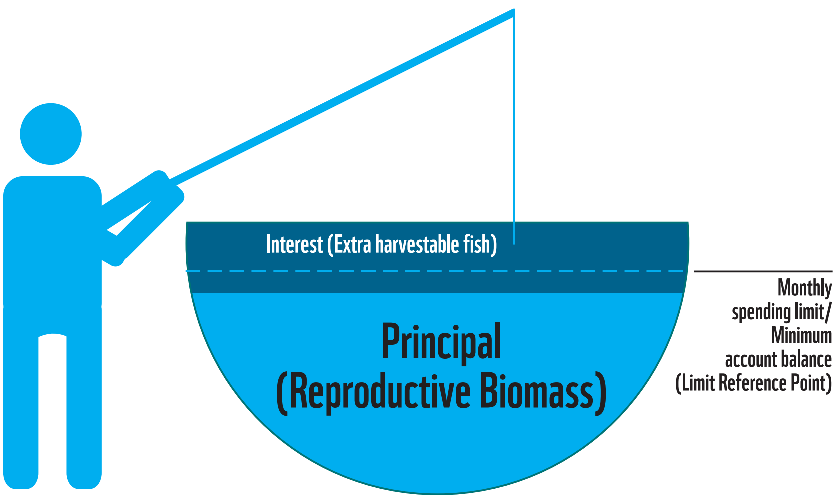

# LIMIT REFERENCE POINT: DON'T GO THERE!

## Reference Points: Single Serving or Packaged Deal?

A Reference Point is a benchmark value that helps managers decide how the fishery is performing and is often based on an indicator such as fish stock size or the level of fishing effort. Fisheries scientists conduct a fish stock assessment to provide estimates of fish stock size and fishing mortality over time. Reference Points serve as a standard to compare those estimates based on our understanding of the biological characteristics of the targeted species. Reference points can mark a limit, which represents a level that managers aim to avoid, or a target, which managers strive to achieve and maintain to best meet the objectives of the fishery (such as stock sustainability or harvest stability). Biological reference points represent specific quantitative indicators of variables such as fishing mortality rate, yield, or stock biomass by which the current state of the fishery and objectives for that fishery can be judged.

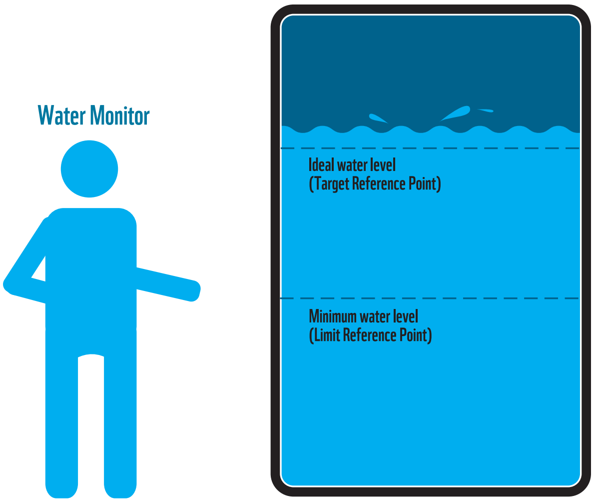
## Example: Bank on a Harvest

Stated in the most basic financial terms, a sustainable fishery is one where fishers harvest only the interest (extra harvestable fish in the population) generated on principal (biomass of fish needed to reproduce itself). Just like with any interest bearing account, if you withdraw all the interest and start withdrawing on the principal in your account, the related interest will decline proportionally along with your principal. A prudent investor also considers variations in the stock market and economy (uncertainty) that may affect the principal, and, therefore, the amount of interest that is generated by a given account. Thus, a rational investor would place a limit on the withdrawal of their interest that would foreseeably prevent them from "digging into their principal." A monthly spending limit or minimum account balance would be analogous to a limit reference point for a bank account that would prevent overspending (and, analogously, overfishing) over a fixed period.



## Example: Keep the Well from Going Dry

Consider also a water tank for a small city or village. When the tank is full, there is plenty of water to go around as regular rainfall replenishes the tank, which is like a healthy fish stock. In this case, the rainfall might be considered the recruitment into the water resource, replenishing the water lost through use in the community (fishing mortality) and natural leaks and evaporation (natural mortality). However, there is a lot of uncertainty regarding recruitment into the water tank through rainfall. The weather, like productivity in the oceans, is uncertain, especially considering climate change! So to ensure that the water tank does not drop too low, a good city manager or mayor will monitor the tank level and try to maintain it at a level that ensures everyone always has adequate water for their needs. This level would represent the target reference point. The manager would also make sure that the tank never reaches a point that, at minimum, the basic needs of the community (such as drinking and cooking) are not met. This would represent a limit reference point similar to that necessary to meet the biological/ecological needs of a fishery. These limit reference points might be interpreted by the manager as a rate of daily water use, like a fishing mortality based reference point, or an absolute minimum physical level that the tank would be allowed to reach, like a stock biomass based reference point.




# LIMIT REFERENCE POINT – SIMILAR TO A RED LIGHT. WHEN YOU APPROACH IT, YOU STOP. IT IS A FISH STOCK SIZE OR LEVEL OF FISHING EFFORT THAT MANAGERS DO NOT WANT TO REACH OR EXCEED. IT TYPICALLY CONSIDERS ONLY THE BIOLOGICAL STATE OF THE STOCK.

## Can Limit Reference Points be set independently of other reference points or management tools?

Absolutely, yes! A Limit Reference Point is based on factors that may be assessed completely independently of other reference points or management measures. Limit Reference Points (LRPs) form the “foundation” or “floor” of the management system as a benchmark that managers and fishermen do not want to go below. Additionally, because LRPs are scientifically established thresholds or limits, they may be set independently of other management considerations (such as target reference points aimed at achieving fishery objectives). Furthermore, because a Limit Reference Point (LRP) is derived exclusively from the best available scientific information on the biological state of the stock, it does not require managers to consider complex social and economic factors necessary for calculating Target Reference Points (TRPs).

**WARNING:** LRPs alone do not ensure the sustainability of a fish stock! An F-based LRP is like a speed limit sign while a B-based LRP is like a stop sign, but both are only effective if a police officer is awake and aware enough to use the radar gun to catch the speeder and their vision to catch the person running the stop sign! Even though LRPs represent a good first step, managers still must have the appropriate TRPs, Harvest Control Rules (HCRs) and Harvest Strategy (HS) in place to ensure a sustainable fishery.

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# TARGET REFERENCE POINTS: AIMING FOR THE RIGHT LEVEL

A Target Reference Point (TRP) is defined by a single or small set of measurable fishery indicators such as fishing mortality rate, yield, or stock biomass that are used to judge if the current state of the fishery is desirable. Unlike a Limit Reference Point (LRP), which is a biologically-based fish stock size or level of fishing that managers seek to avoid, a TRP represents a fish stock size or level of fishing which managers strive to achieve and maintain to best meet the management objectives of the fishery (such as stock sustainability or harvest stability). A TRP incorporates biological, ecological, social, and economic considerations. It should never be lower than the LRP and should be sufficiently higher to ensure managers have a buffer to account for information that is uncertain.

## Example: Generating Wealth through Good Investments in Sustainability

Establishing a TRP requires considering and balancing several interests to ensure ecological sustainability as well as economic viability and social/cultural benefits of the fishery. However, doing so requires that fishermen and managers determine what the objectives of the fishery will be. For instance, existing fishermen could desire high profit margins through limited fishing access rights and resulting high stock sizes. Alternatively, governments could desire a high level of employment with lower profit margins associated with a large fleet size. Other considerations might include limits on gear types or techniques that favour a particular social goal, such as a preference for artisanal hand line fishing that benefits the traditional and cultural aspects of a particular region. These preferences and interests, also known as “management objectives”, must be determined and a balance among competing objectives sought before a representative TRP can be selected. However, managers may elect to select a precautionary TRP in the interim as a benchmark for future development of a more refined TRP that adequately balances all management objectives.

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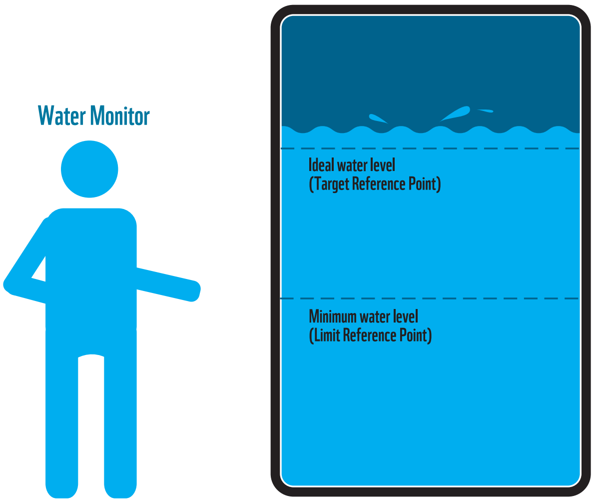
## Example: Keep the Water Flowing

Consider again the water tank for a small city or village addressed in the LRP: DON'T GO THERE discussion. When the tank is full, there is plenty of water to go around as regular rainfall replenishes the tank, which is like a healthy fish stock. Recall that rainfall represents the recruitment into the water resource, replenishing the water lost through use in the community (fishing mortality) and natural leaks and evaporation (natural mortality). Weather and climate variation represent uncertainty. To ensure that the water tank does not drop too low, a good city manager or mayor will monitor the tank level and try to maintain it at a level that ensures everyone always has adequate water for their needs. This level could represent the target reference point. The Manager might consider certain management objectives, such as ensuring enough water to allow a full load of laundry to be done every day by every member of the village. The manager might also consider reducing the water allotment for individual laundry in favour of allowing greater irrigation of crops. In either case, the goal is to maintain the water tank at a target level that meets the management objectives while accounting for information uncertainty that otherwise might lead to an accidental breaching of the LRP. Like with LRPs, TRPs might be interpreted by the manager as a rate of daily water use (akin to a fishing mortality based reference point) or simply the desired level of water in the tank (akin to a stock biomass based reference point).




## How much distance should there be between the LRP and TRP?

The best answer is "it depends." If there is a large degree of uncertainty in the science used to assess the fishery, there should be a larger "buffer" between the LRP and TRP. The lower the uncertainty, a smaller buffer can be justified. Information uncertainty can be substantially reduced by improving measures for recordkeeping and reporting in the fishery.

**WARNING:** Setting TRPs alone does not ensure the target will be met! Strong monitoring, control, and surveillance mechanisms must be in place to not only properly implement management measures and ensure compliance, but also to ensure that the appropriate information is collected and incorporated into stock assessments. You cannot know if you are achieving the target (i.e., your objectives) if you do not have the information to indicate where the stock level is in relation to the TRP.



# UNCERTAINTY:
# ACCOUNTING FOR WHAT WE DON'T KNOW

"THERE ARE KNOWN KNOWNS. THESE ARE THINGS WE KNOW THAT WE KNOW. THERE ARE KNOWN UNKNOWNS. THAT IS TO SAY, THERE ARE THINGS THAT WE KNOW WE DON'T KNOW. BUT THERE ARE ALSO UNKNOWN UNKNOWNS. THERE ARE THINGS WE DON'T KNOW WE DON'T KNOW." **DONALD RUMSFELD, U.S. SECRETARY OF DEFENSE FROM 2001 TO 2006 UNDER PRESIDENT GEORGE W. BUSH.**

## What is Uncertainty?

Uncertainty is concisely defined as "The incompleteness of knowledge about the state or process of nature" (FAO/Govt. of Sweden 1995). For our purposes, uncertainty is simply information that we do not know about for a fishery that could affect the risk of breaching a Limit Reference Point (LRP). There are several sources of uncertainty that should be considered when calculating Reference Points and in the evaluation of stock status relative to these reference points. There are five main types of uncertainty that can arise from imprecise or incomplete knowledge or information about the state of a fishery.

### 1. Uncertainty due to Measurement Error and Bias

Measurement error and bias can result from incomplete or inaccurate data collection of catch, fishing effort, or biological samples (e.g.,length/weight of catch, age and maturity of fish). Standard statistical problems of sample size and representativeness also complicate this kind of uncertainty. Misreporting in logbooks and other reporting documents can lead to bias. Also, effort creep, or undetected increases in fishing power due to fisherman learning new techniques and technological change, can further create substantial errors and bias in understanding the catch-effort relationship.

### 2. Process Uncertainty

Process uncertainty relates to how we understand the natural world and can occur over short or long time scales. Environmental variability, a large source of process errors, usually manifests itself as recruitment variability. Recruitment variability can lead to large fluctuations in the amount of fish biomass available to catch depending on the species. Because of the difficulty in predicting environmental conditions and the subsequent response of fish populations to those conditions sufficiently far into the future to be useful for management, recruitment variability is often treated as stochastic (or random).

## 3. Model Uncertainty

Model uncertainty relates to the inability to perfectly capture the true behaviour of fish populations (and how they interact with fishing) with mathematical and statistical models that are used to conduct stock assessments. This type of uncertainty can arise from unknown errors in the assumptions of variables used in equations designed to calculate stock dynamics. Model error can be examined to some extent by evaluating multiple models for the same resource, but this often cannot be exhaustive due to a lack of data or resources (expertise, computation time, funding).

## 4. Estimation Uncertainty

Estimation errors occur because the data and the processes being modelled are never perfect. Estimation errors that result from unknown biases or trends in input variables may be very difficult to detect or describe, but can lead to large overall errors in a stock assessment. One dramatic example is the systematic bias that can result in estimates of stock abundance when using the common approach of modelling a population by following individual cohorts through time (so-called "retrospective bias").

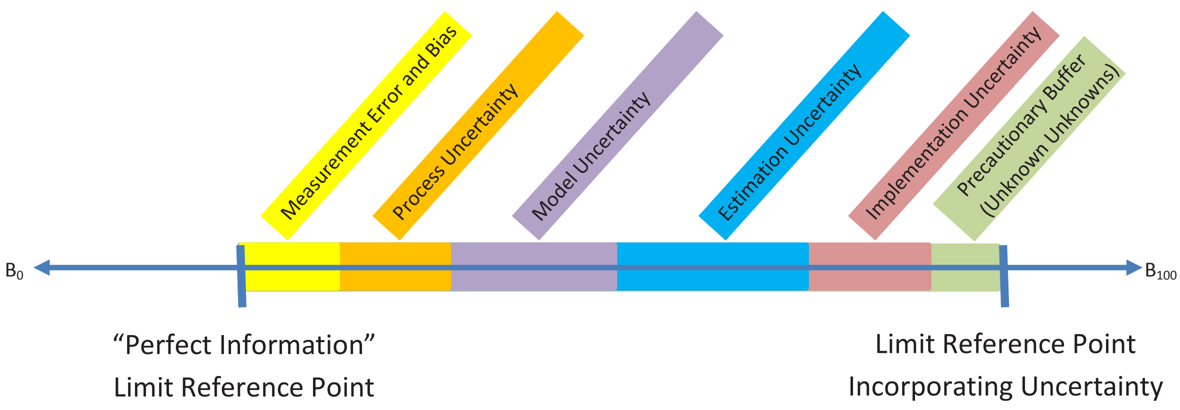
## 5. Implementation Uncertainty

Implementation uncertainty generally lies outside the scientific component of uncertainty, representing unknowns related to the fact that management decisions are never implemented 'on the water' perfectly. This largely consists of a failure to control exploitation by the Monitoring, Control and Surveillance (MCS) measures that have been adopted. These failures may include poor surveillance and enforcement, lack of concern by the judiciary when cases are heard, failure of participants to support measures due to lack of opportunity for input during their development, or simply disagreement with the measures enforced. Unfortunately, this kind of uncertainty can represent a major cause for the failure to conserve stocks despite excellent stock assessments.

These are the main types of uncertainty that are inherent to fisheries science and management. Each type can exist independently or concurrently with the other types, but it is important to remember that all types of uncertainty are cumulative in their effect.

## How to Deal with Uncertainty

Uncertainty in information the leads to management decisions can increase the risk that something "bad" could happen despite managers best efforts to properly manage the fishery. While managers can work to reduce uncertainty through the use of better data, enhanced models, or improved implementation, they can never completely eliminate uncertainty. Thus, it is most important to acknowledge the key sources of uncertainty and be precautionary in addressing uncertainty by allowing an effective buffer around a Reference Point – thus taking the "unknown" sources as well as the quantifiable sources of uncertainty into account.



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# RISK: DETERMINING ACCEPTABLE LOSS

## What is Risk?

Risk may be generally defined as "the probability of something bad happening." Therefore, with respect to decision making in fisheries management, risk is the average loss or forecasted loss of something bad happening. Risk is related to uncertainty because there is inherently more risk associated with uncertain outcomes.

The level of risk that is acceptable to managers is ultimately a policy choice. Managers must define acceptable levels of risk and of short-term yield which can be foregone to reduce these risks. In general, managers should be willing to accept a lower risk tolerance as data and knowledge improve thereby reducing the amount of uncertainty.

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## Determining Risk in Light of Uncertainty

Clearly, when management decisions are to be based on estimates from fishery assessment models, it is desirable that the level of uncertainty be quantified, and used to calculate the probability that a particular management action will achieve the desired target and/or risk of incurring undesirable events, such as exceeding the Limit Reference Point (LRP).

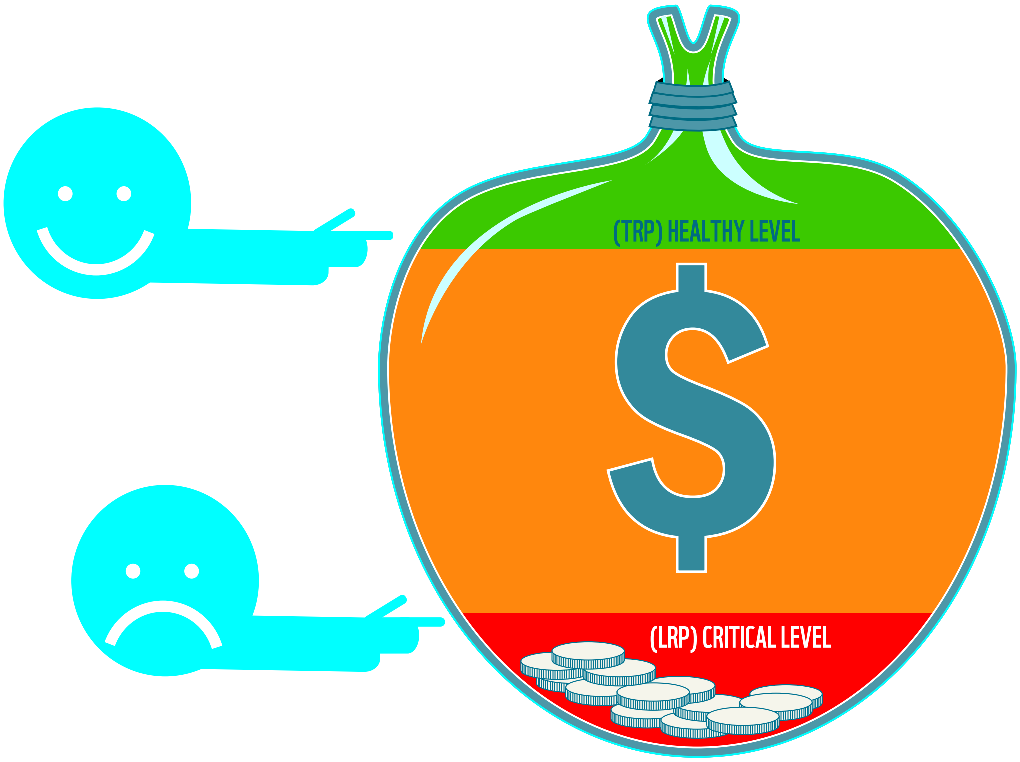
When a large degree of uncertainty exists, it necessarily requires that the Target Reference Point (TRP) be set more conservatively to ensure that the LRP is not breached. When more information is available to managers, such as operational data and tagging data, it may reduce uncertainty and improve estimates such that the TRP could be placed closer to the LRP.

Likewise, when uncertainty is high, it is reasonable to set a lower percentage of risk of breaching a LRP. A lower probability of risk of breaching an LRP ensures that uncertainty is adequately accounted for. Alternatively, when more information is made available, the probability of risk may reasonably be reduced to a higher percentage.

## Assessing Risk

A thorough assessment of risk requires that scientists quantify the degree to which the events are deemed undesirable by managers/stakeholders; that is, the cost or impact of the event. This requires weighing the outcomes against the potential costs and benefits. Increased catches are generally accompanied by reduced biomass in fisheries with associated risks of variability and stock collapse. At the core, the simple risk assessment is, "How much catch can be taken without reducing the stock to the point where it may fluctuate unacceptably, and/or be unable to replenish itself". Other questions of risk may consider various management objectives or combinations of management objectives and, ultimately, more complex social and economic issues.

One of the biggest challenges for managers is determining what is "acceptable risk." For example, some have proposed a definition in which the level of harvesting should be considered safe if it maintains the spawning stock biomass above 20% of the virgin stock level at least 90% of the time. Definitions of acceptable risk will generally be stated in similar terms, but in every case it will be fishery specific and tied to the management objectives.




## Categories of Risk

Two general categories of risk can be identified: the risk of not achieving a TRP, and the risk of exceeding an LRP. The costs of not achieving a TRP, by being either too high or too low, are usually defined in terms of the short-term reduction or interruption of the flow of benefits to participants in the fishery and consumers, even though this may result in a net gain in the long term.

The costs of exceeding an LRP are much more serious, ranging from stock decline to collapse, impacts on associated species and ecosystem destabilization, long term loss of earnings, including intergenerational impacts for both fish stocks and fishermen.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# HARVEST CONTROL RULES: STREAMLINING FISHERIES DECISION MAKING AND SUSTAINABILITY

A Harvest Control Rule (HCR) is a pre-agreed action, or set of actions, to be taken by a management body designed to achieve a medium or long-term target stock size (the Target Reference Point or "TRP") while avoiding stock levels that pose a risk to sustainability (the Limit Reference Point or "LRP"). Simple HCRs can be described as an "if, then" statement. An example of a very simple HCR would be "if the fishery stock level falls below the target level, then the level of fishing must be reduced by 20%." Managers may also agree in advance what the specific management actions would be to reach the 20% reduction in the level of fishing, such as a regional closure or gear restriction.

**Other basic examples of HCRs depend on the management objectives of the fishery, but might include:**

1. Total Allowable Catch: Fisheries are managed by a total allowable catch (TAC). A maximum TAC is set for each stock so that the respective target biomass is maintained on average. This maximum TAC may be taken as long as biomass fluctuations remain above a TRP.
2. TAC Reductions: If the biomass falls below a TRP, then the TAC is linearly reduced, as a function of biomass, to reach zero catch at an LRP.
3. Mixed Fisheries: In fisheries where several target species are caught with the same gear, the maximum TACs for the respective stocks are set such that the most sensitive stocks do not fall below a TRP on average over a specified number of years, with a high probability of not falling below an LRP (also known as "weak stock management").
4. Discard: No discard of commercially exploited species are allowed, except for species with a demonstrated high discard survival rate.
5. Bycatch: Ecological risk assessments are conducted on bycatch species and to assess potential damage to the environment caused by fishing, with respective measures to be taken to minimize risk.
6. Size structure: The mean size and age in the catch are adjusted to minimize changes in age structure caused by fishing, and to reduce the potential for driving artificial selection leading to smaller individual fish sizes over time.

## Example: Automating the Process

To recall the water tank analogy, when the water level starts to decline in the tank to concerning levels, the manager must take steps to reduce the consumption of that resource, either by placing restrictions on how it is used or otherwise limiting how much is used. This would be very difficult if every time this occurred he had to negotiate with every person in the village as to how water is distributed. In fact, by the time the manager negotiates with every person to meet their individual needs, he might find that the tank is dry! What the manager needs is an automatic measure in place to maintain the a water tank level such that a sufficient water level is maintained for all the community members that, in turn, negates the need for excessive deliberation by allowing community members to decide in advance what steps need to be taken in the event of a shortage. For instance, the community members decide when and where the cuts need to be made in advance of a situation that requires making those kinds of difficult decisions. Similarly, an HCR can act as an automatic measure to ensure that management objectives of a fishery, including stock levels, are maintained within agreed parameters without having to go through the extensive, time consuming, and often times, non-transparent process of establishing new management measures.

## Creating More Transparent and Responsive Management through Harvest Control Rules

Current management of the tuna fisheries relies on annual decision-making processes that can be heavily influenced by sporadic, and sometimes unrelated, political factors. These factors and other considerations can lead to bureaucratic gridlock and inaction even when the biological, ecological, or socioeconomic situation calls for swift and decisive action. Using pre-established Reference Points and well-defined HCRs minimizes excessive debate, allowing managers to act quickly and decisively when the fishery reaches a pre-defined threshold (e.g. LRP or TRP).



## Key features of HCRs:

- Streamline and facilitate informed management decisions;
- Improve transparency and accessibility of harvest management decisions;
- Set and confirm clear, distinct targets and limits;
- Define explicit intended responses to changes in stock status;
- Lay the foundation for developing well-defined fisheries management plans that are grounded in sound science; and
- Promote sustainability.

## Proven Tool for Effective Fisheries Management

Harvest Control Rules are a well-established and proven tool in fisheries management. The best managed and most productive fisheries in the world rely on a combination of Limit and Target Reference Points in concert with well-defined Harvest Control Rules to manage their fisheries!


# FISHING WITHIN LIMITS

## Ensuring Sustainability through Technical Measures for the Efficient, Consistent, and Reliable Management of Fisheries

Currently, fisheries in the Western Central Pacific Ocean (WCPO) are subject to management measures imposed on a relatively opportunistic basis under a consensus-based system subject to many competing interests and values. The broad range of competing interests can often lead to decisions that maximize short-term economic interests at the expense of long-term productivity and sustainability, which can further lead to wide variation in catch levels and, potentially, overfishing and inconsistent market supply.  Implementation of Harvest Policies that are guided by Reference Points and Harvest Control Rules allow managers to act swiftly and efficiently under a pre-agreed standard to ensure that harvest does not exceed any acceptable limits, thereby ensuring the sustainability of the resource and the consistent supply of fish to our markets.

**An example of a very basic Harvest Strategy might include the following:**

- Maintain fish stocks, on average, at a Target Reference Point (TRP) equal to a stock size that results in an optimal level of economic gain from the fishery (e.g., maximum economic yield);
- Ensure that stocks remain consistently above a level that ensures  the risk of overfishing is tolerably small, or the Trigger Reference Point;
- Ensure that stocks always stay biologically healthy, or above the Limit Reference Point; and
- If a stock goes below the Limit Reference Point (LRP), managers must automatically enact the rebuilding plan to allow the stock to rebuild towards the TRP.

As you can see, efforts to define Reference Points and Harvest Control Rules help to clearly inform the Harvest Strategy. Ultimately, the Harvest Strategy represents an important part of any management plan that specifies what information is collected, how that information is analysed to assess stock status, and the criteria for how assessment results are used to determine the next set of management actions.  Thus, the main components involved in defining a Harvest Strategy include:

- the collection of data from the fishery, including fishery independent survey data and environmental data,
- the analysis of this data in an assessment process,
- the calculation of the value of indicators used in an HCR, and
- the use of a decision rule to determine the level of fishing for the subsequent year (e.g. setting a TAE or TAC).

In essence, a Harvest Strategy is like an operations manual for a complex piece of machinery. It does not necessarily tell you every detail of every part, but provides a clear indication of the input and steps necessary to make the machine work. Most importantly, a well-defined Harvest Strategy can "keep the machine running" by helping to guard against overfishing and ensure stability and, in turn, profitability in the fishery.

## MANAGEMENT STRATEGY EVALUATION: WILL THE HARVEST STRATEGY WORK OR, LATER, IS IT WORKING?

In order to decide which harvest strategy is likely to work as intended by best meeting your management objectives, a Harvest Strategy must be carefully and methodically evaluated both during its initial development and, periodically, after its implementation. One way this can be accomplished is by comparing the expected relative performance of alternative harvest strategies using simulation modelling in a process known as Management Strategy Evaluation (MSE).

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**From a broad view, the MSE approach involves the following four components:**

- Specification of operational objectives from higher level management goals;
- Identification of performance measures for each objective;
- Specification of alternative management or harvest strategies to be evaluated; and
- A method of evaluation that provides an assessment of likely performance for any proposed management strategy as well as a basis for comparing the relative performance of possible alternatives.

Fisheries scientists developed the MSE approach in recognition of the inherent uncertainty in our knowledge of past and current fish stock status, a fish stock's response to different harvest levels, and current and future productivity of a given stock. The focus of MSE is to identify management strategies that are robust to known and plausible sources of uncertainty in the fishery. In other words, it provides a basis to identify strategies that are likely to meet objectives in spite of the uncertainty in the status and dynamics of the fishery and its response to different levels of harvest and management.

By using several different models to estimate future populations based on the current and historic state of the fishery through MSE, managers may focus on the evaluation of strategies that are likely to meet specified management objectives and, as a result, the Harvest Strategy despite uncertainties. Thus, the review and perspective offered through the MSE process ensures that managers can make informed decisions in attempts to maximise the potential of the fishery while simultaneously protecting its sustainability

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## High impact Initiatives

Over the next 5 years we will accelerate our on-ground conservation and advocacy work, focusing on priority areas where we have the greatest impact and influence.

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Through building influential relationships with business and industry, we will continue to create solutions to address the major threats to our natural environment.

**Why we are here**
To stop the degradation of the planet's natural environment and to build a future in which humans live in harmony with nature.

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