

Harvest strategies and control rules (HCRs) in multispecies fisheries across the world – A compilation of recent developments and its lessons for India

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Background

India's marine fisheries are unique because of their tropical character and are complex to manage as they are multispecies and multigear in nature. From the middle of the last century, concerted research efforts have been made in India to develop a scientific catch and effort monitoring system and develop methodologies for the assessment of commercially important fish stocks. Although much progress has been made in stock assessments using length-based and catch/effort-based models, very few of these have been successfully translated into management actions by the concerned agencies. This is primarily because of the lack of development of a comprehensive management strategy and procedure.

Harvest strategies, also called management procedures, represent the latest generation of science-based approaches to effective fisheries management. When properly developed, these full-cycle strategies start with precise management objectives and include monitoring of the stock after implementation so managers and stakeholders have a clear sense of the best path forward for the fish and the fishery.

Harvest control rules (HCRs) are the operational component of a harvest strategy, essentially pre-agreed guidelines that determine how much fishing can take place, based on indicators of the targeted stock's status. These indicators can be based on either monitoring data or models. For empirical harvest control rules, the indicators come from one or more direct measures of stock status, such as an abundance survey or calculations of how much effort it takes to fish, known as the catch per unit effort (CPUE) index. For model-based HCRs, an abundance level estimated by a stock assessment model is typically the indicator.

Harvest strategies and control rules are difficult to impose in multispecies fishery because of the large number of species involved. Catch quota limits or area closures imposed on one species affects the fishery of other species too.

Different fisheries across the world have tried to tackle this through a combination of various methods. This article tries to compile the methods used by some of these fisheries and discusses the possibility of application of these in India, particularly to multispecies trawl fisheries.

US Groundfish trawl fishery

The fishery consisted of 13 Marine Stewardship Council (MSC) certification candidate species and 17 units of certification. The fishery is managed by the National Marine Fisheries Service (NMFS). There were around 30 plus bycatch species also listed.

Federal groundfish regulations include groundfish harvest levels and fishing restrictions (trip limits, area closures, season lengths, etc.), which are known as the "harvest specifications and management measures." The NMFS publishes the Pacific Coast Groundfish Biennial Specifications and Management Measures before the start of the fishing year. Throughout the following two years, NMFS amends these regulations in-season, either to correct mistakes or to revise trip limits or other management measures according to recommendations from the Pacific Fishery Management Council (NMFS, 2011). Management measures constrain catch to within the Allowable Catch Limits (ACL) for both non-overfished and overfished stocks and are also directed at achieving socioeconomic and equitable utilization goals and objectives outlined in the FMP.

The groundfish limited entry program is an important fixed element of the management framework. Under this program, a vessel must be registered to one of a fixed number of permits to fish for groundfish. The limited entry program creates several sectors, around which management measures are designed.

The primary harvest control measures for commercial fisheries are applied differently to each of these sectors and include the following:

- Two-month or monthly cumulative landing limits (trip limits)
- Gear requirements, principally relating to trawl gear

- Time and area closures. For example, groundfish conservation areas (GCAs) prohibit vessels from fishing in depths where overfished groundfish species are more abundant. GCAs include coastwide rockfish conservation areas (RCAs) and more geographically discrete Cowcod Conservation Areas (CCAs) in the Southern California Bight and Yelloweye Rockfish Conservation Areas (YRCAs) off Oregon and Washington.
- Bycatch limits for the Pacific whiting sectors for select overfished species (PFMC, 2011)
- New management measures added to alter the system of harvest controls used in the bottom trawl sector.
- IFQ (Individual Fishing Quota) management for a single shoreside sector combining vessels targeting whiting and non-whiting species and delivering to shore-based locations. IFQs replace the current 2-month cumulative trip limits for most species (some infrequently caught non-overfished species will still be managed with trip limits).
- A 2-year moratorium on the transfer of quota shares (QS)
- Accumulation limits on QS
- Set-asides: a set-aside is an amount of yield dedicated to a particular activity. If a set-aside is overestimated, unharvested amounts are unavailable for harvest by other fishery participants. Set-asides are in contrast to yield amounts taken “off the top” of an ACL to account for a potential harvest. If off the-top amounts are overestimated, management measures can be adjusted during the biennial period to allow other fisheries to harvest unused amounts.
- Individual bycatch quota (IBQ) for Pacific halibut
- Gear switching provision that allows IFQ to be fished with any legal groundfish gear type.

Amendment 20 introduced a new system of monitoring and surveillance with significantly expanded coverage. Amendment 20 includes a tracking and monitoring program to assure that all IFQ trawl groundfish catch (including discards) is documented and matched against Quota Pounds QP. Observers are required on all vessels and catch monitors are required during all offloading. This represents an increase in catch tracking and monitoring compared to the previous (pre-rationalization) level. NMFS has worked closely with the States and the

Council to develop the details of the tracking and monitoring program that has several monitoring attributes. NMFS-certified at-sea observers are required on each vessel to:

- Account for catch and bycatch
- Record fishing effort
- Estimate the total, retained and discarded catch weight by species
- Determine species composition of retained and discarded catch
- Document the reasons for discard
- Record interactions and sightings of protected species
- Take biological samples from tagged fish and discards
- Estimate the viability of Pacific halibut
- Monitor the use of individual bycatch quota in the fishery
- Weigh and account for discarding of halibut bycatch

US Acadian Redfish, Pollock and Haddock Otter Trawl Fishery

The fishery is a multispecies fishery with four species and four Units of certification in New England. It is managed by the New England Fisheries Management Council (NEFMC) through the Northeast Multispecies Fishery Management Plan (NE Multispecies FMP).

Originally enacted in 1985, the NE Multispecies FMP has been amended several times to improve the management of the relevant fisheries, including the introduction of gear restrictions (e.g. mesh size, number of nets/hooks etc.), seasonal closures, spatial closures, minimum landing sizes, trip limits on the poundage of fish landed, limited access (a restriction on the number of vessels able to work within the fishery), effort limits based on days-at-sea (DAS) system, and most recently a system based on transferable quotas set against a hard annual catch limit (ACL). In 2010, Amendment 16 to the NE Multispecies FMP greatly expanded catch share, or sector-based, management. The sectors function essentially as cooperatives, as they are self-selecting and largely self-regulating; albeit within a framework designated and closely monitored by federal agencies. The sectors are exempt from many of the effort controls previously used to manage the fishery; instead, they adhere to an overall hard quota known as an ACL, which is subdivided into Annual Catch Entitlements (ACE) allocated to each sector. The shift to output management instead of effort management enables efficiency gains by allowing increased operational efficiency.

Under the US Magnuson-Stevens Act, the Annual Catch Limit (ACL) must be set less than or equal to the Acceptable Biological Catch (ABC=MSY) to account for management uncertainty, which must be set less than or equal to the Overfishing Level (OFL) (to account for any scientific uncertainty in the stock assessment) (Figure 1). Fishing mortality targets are set for each stock independently based on achieving MSY in the long term, therefore for stocks that are overfished (and may also be subject to overfishing) the target fishing mortality is set at a level that will have a reasonable probability (>50%) of ensuring rebuilding of the stock within the timeline set within the relevant rebuilding program. However, should a sector approach the ACE for one of the target stocks, then the area inhabited by that stock is closed to all gears capable of catching that stock, resulting in a potential 'under-harvest' of more abundant stocks. The sector system allows fishermen to share trade or lease quota within a fishery, reducing the chance of overfishing depleted stocks while targeting more abundant stocks; and if a sector is nearing its quota for a particular species, it may be possible to lease it from another sector.

With the new management strategy, discarding appears to have been reduced, and the fishery now relies on hard ACLs (which include discards) rather than target TACs, all of which helps reduce the likelihood of exceeding sustainable fishing mortality rates for targeted stocks.

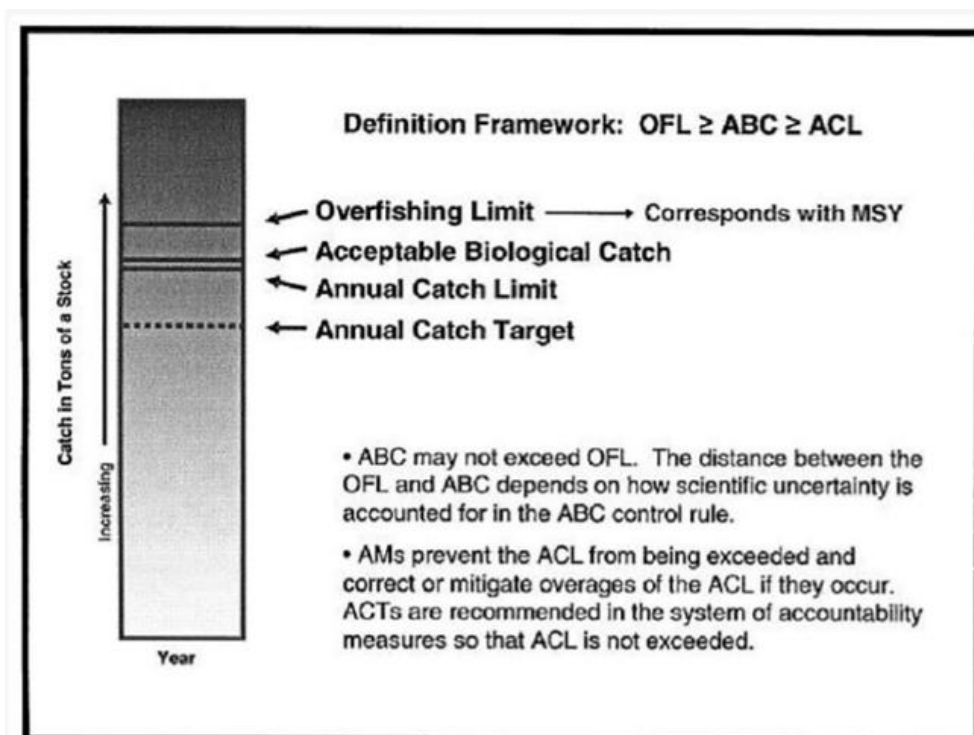


Fig: 1. Relationship between OFL, ABC, ACL and ACT as described by the National Marine Fisheries Service (NOAA 2009). Source: Ivan et al., US Acadian Redfish, Pollock and Haddock Otter Trawl Fishery, MSC Final assessment report

ISF Iceland Multi-Species Demersal Fishery

A multispecies multigear fishery with seven species harvested by six gears within the Icelandic Exclusive Economic Zone (EEZ), North-east Atlantic, and ICES division. The management strategy for the seven principle species is to maintain the exploitation rate at the rate which is consistent with the precautionary approach (PA) that generates MSY in the long run.

The harvest strategy is based on F_{msy} or its proxy. Harvest control rules are based on fishing mortality modified in response to changes in stock status. For data-limited stocks immediate management measures are taken to revive the stocks.

The tools used to regulate these seven fisheries are similar. Quotas expressed as an annual Total Allowable Catch (TAC), are the primary tools used to control fishing effort and thus fishing mortality. With some minor exceptions, it is required by law to land all catches; discarding is banned. Consequently, no minimum landing size is in force.

A system of transferable boat quotas was introduced in 1984. This system has resulted in boats having diverse species portfolios, with companies often concentrating/specializing on a particular group of species. The system allows for some, but limited, flexibility with regards to converting a quota share of one species into another within a boat, allowance of landings of fish under a certain size without it counting fully in weight towards the quota, and allowance of transfer of unfished quota between management years. The objective of these measures is to minimize discarding, which is effectively banned for commercial species. Since 2006/2007, all boats have operated under the TAC system (WGDEEP, 2018).

To prevent the fishing of small fish, various measures, such as a mesh size regulation and closures of fishing areas, are in place. A system of instant area closures is also in place for many species. The system aims to minimize fishing on juveniles. Data on discards is available from observers, for which there is about 1% coverage of the Icelandic multispecies fishery.

Greenland Cod, Haddock and Saithe Trawl Fishery in the Barents Sea

The fishery is a mixed trawl fishery with cod as a target species together with haddock and saithe. Vessels from Norway, Russia, the EU, Faroe Islands and Greenland all operate in the fishery. The Norwegian management plan aims at maintaining high long-term yield and year-to-year stability of catches.

Norwegian fishing regulations for the Barents Sea include area closures; seasonal closures; a list of species which are prohibited to target; the need for certified catch-weighting equipment on board (with an accepted “error margin” for the declared weight of +/-5%); and reporting systems and requirements(<http://www.fiskeridir.no/english/fisheries/regulations>). By-catch levels are prescribed for each species. If bycatch is above any of these maximum levels, the vessel shall release the catch into the sea with minimum damage possible and change fishing position by a minimum of 5 nm. This action shall be recorded in the relevant documents and relevant authorities informed. All allowable bycatch must be registered in log-books.

There is a robust discard ban which covers all waters of the assessed fishery and, and combined with the initiatives and management measures listed above, makes sure that there is no discarding of fish in the Unit of Certification.

Lessons for India on managing multispecies multigear fisheries

The tropical Indian marine fishery resources are unique at least on three factors: (i) Many species have wide spatial distribution, (ii) Several species show wide temporal variations in abundance, and (iii) Since the resources cannot be seen visually, gaining an insight into the structure and function of the resources is a challenge (Vivekanandan, 2005). Besides, the number of species exploited in each gear is very large (Sathianandan et al., 2013) and some of the species are exploited by several widely differing gears (multigear). These species are also characterized by widely different life-history traits such as very short-lived to very long-lived, *r*-selected to *k*-selected reproductive strategies etc, However, much progress has been made in stock assessment and management despite these challenges. To improve the management system in the light of recent global best-practices described above the following actions are recommended.

1. Introduce statements on management and harvest strategy into respective fisheries laws and regulations so that the objectives are clear and unambiguous.
2. Identify and name each fishery based on gear (in the case of multispecies and multigear fisheries) and location/region or species gear and location in the case of unique species fishery.
3. Decide on the species to be assessed in each fishery based on an objective criterion. For example, (i) high-value catch (HVC) - fishes, crustaceans and molluscs, which are directly used for human consumption; (ii) low-value bycatch (LVB) - not used for human consumption, but used in fish meal plants, which include juveniles of high-value fishes and adults of small-sized fishes; and (iii) discards-at-sea, which include non-edible and occasionally edible biota (Dineshbabu et al., 2013). However, this classification does not identify the species to be assessed for stock-status. The term target species, non-target species and bycatch may be more appropriate.
4. Use an objective criterion to decide on the frequency of stock assessments for each species in a fishery. Kuriakose et al., (2020) has already described criteria to decide this based on life-history traits of the species.
5. To overcome the challenges in administering and regulating marine fisheries in the Indian EEZ under central government administration (area 1.86 million km², which is 92% of the total 2.02 million km²), a zonal management system has been proposed (Mohamed et al., 2019). Zonal management is a way to delineate areas of the coastal and marine environment to specific allowable or prohibited activities in time or space and conduct fish stock assessments for these specific areas.
6. Adopt a suitable (single species/ multispecies/ multigear) stock assessment methodology that is state-of-the-art and keeping with the data available and vulnerability or resilience of the species/species complex to fishing. Once the reference points for each stock and fishery are derived, the HCRs have to be developed for each fishery before passing this on as an FMP advisory to the management agencies (State or Central).
7. A switch to a total allowable catch (TAC) and a quota system has also been recommended by Mohamed et al. (2019). The advantages of zonal management, TAC system and fleet wise quotas, besides the approach to determining and apportioning quotas have been proposed, but needs to be done as a pilot study.

By following the above guidance, managers of trawl fisheries who are frequently faced with the need to reconcile multiple and often conflicting societal, environmental and economic objectives can resolve many problems with time. Foremost among the management objectives is usually the need for sustainable exploitation of the targeted stocks resulting in employment, income and food security. In most countries and regions, there are also stated objectives to accomplish this exploitation with minimal habitat impacts or losses of ecosystem services and to ensure the unintended bycatch is minimized.

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