Designing and Implementing Annual Catch Limits for North Pacific Groundfish and Crab Stocks

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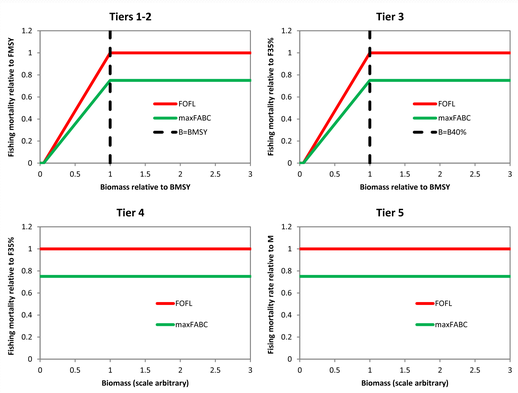
Abstract: The Alaska Fisheries Science Center (AFSC) provides the main stock assessment support to the North Pacific Fishery Management Council (NPFMC) for Bering Sea/Aleutians and Gulf of Alaska groundfish and for some Bering Sea/Aleutian Islands crab stocks. Stock assessment scientists have been instrumental in the development of the groundfish and crab tier systems, which define harvest control rules that vary according to the type of information available. A number of changes have occurred in these tier systems in order to meet the annual catch limit (ACL) requirements of the Magnuson Act. In addition, vulnerability assessments have been used to guide the assignment of species/complexes to the ecosystem component management category. Different methods have been evolving for dealing with uncertainty and data poor complexes; some of these approaches will also be highlighted.

Groundfish tier system

Tiers grouped by basis and information availability

- Tiers 1-2 are based on MSY directly
  - Tier 1 is used when uncertainty can be estimated
  - Tier 2 is used when uncertainty cannot be estimated
- Tiers 3-4 are based on relative spawning per recruit
  - Tier 3 is used when recruitment can be estimated
  - Tier 4 is used when recruitment cannot be estimated
- Tier 5 is based on natural mortality rate ("M")
- Tier 6 is based (usually) on catch time series

Example F_{OFL} and $maxF_{ABC}$ control rules (Tiers 1-5)



Reference points used in the tiers
(Best point estimates used in all cases)

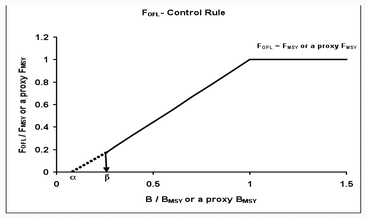
- Tier 1 uses BMSY, FMSY, and FMSY uncertainty
- Tier 2 uses BMSY and FMSY
- Tier 3 uses B40%, F35%, and F40%
- Tier 4 uses F35% and F40%
- Tier 5 uses current biomass and natural mortality rate
- Tier 6 uses average catch (usually)
  - FMPs allow SSC to use a different measure if appropriate

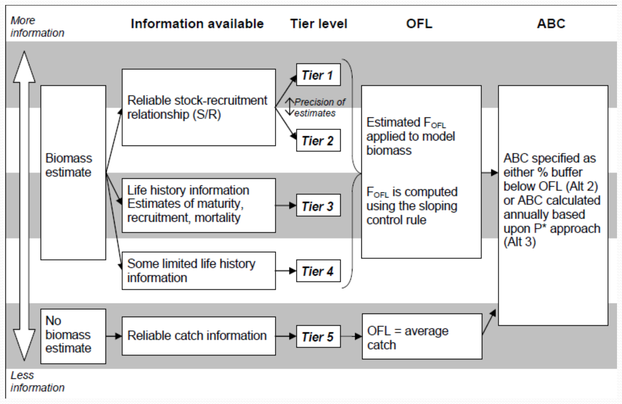
Other features of the groundfish tier system

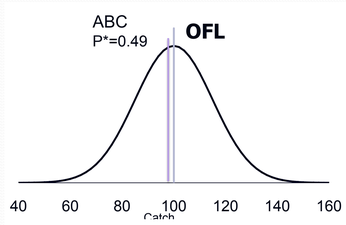
- Form of F_{OFL} control rules has been constant since 1990
- Minimum buffer between OFL and ABC prescribed for all tiers
  - These have been in place, with some changes, since 1996
  - Larger buffers can be set at SSC's discretion in special cases
- Minimum buffer in Tier 1 varies directly with FMSY uncertainty
- Minimum buffers in Tiers 2-6 are "fixed"
  - That is, they do not vary directly with uncertainty
  - Preliminary analysis indicates that they correspond, on average, to a 12% probability of exceeding the "true" OFL
- Exploration of alternative harvest control rules is ongoing
  - "*P** approach" would specify a variable buffer for all tiers
  - Decision theory could be used to optimize buffers
- For principal prey species of endangered Steller sea lions, directed fishery will be closed if biomass falls below B20%
- Vertical axis for Tier 6 is catch rather than fishing mortality
  - But see "Alternative Tier 6 approaches" below

Crab tier system

Overfishing rule limits catch to prevent overfishing and avoid overfished status (0.5 B_{MSY})
Set by OFL fishing mortality rate (F_{OFL})
F_{OFL} prescribed by Tier system
Stock $\geq B_{MSY}$: $F_{OFL} = F_{MSY}$
Stock $< B_{MSY}$: $F_{OFL} < F_{MSY}$







- P* is the probability that the estimate of max ABC exceeds the "true" OFL.
- P* = 0.49 for Bering Sea/Aleutians crab stocks. This results in virtually no uncertainty buffer between maxABC and OFL, with the Council intent of additional uncertainty being incorporated through the State of Alaska harvest controls, which are separate from this system.
- However, recent NPFMC SSC practice has been to specify ABC below the maximum permissable, typically with a 10% buffer between the OFL and ABC for Tier 1-4 Bering sea crab stocks.
- Tier 5 stocks have a 10% buffer built in between the specified OFL and max ABC.

Alternative Tier 6 approaches

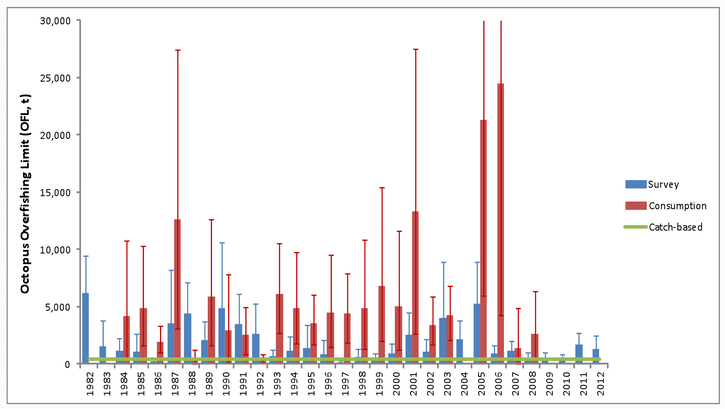
Data poor or catch-only stocks for groundfish are in Tier 6 which uses reliable catch history information to determine OFL and ABC. In recent, years, the NPFMC SSC has encouraged the development of alternative Tier 6 approaches for species in which the catch is not considered a reliable indicator of potential sustainable production. Non-target species such as octopus and sharks that are in the FMP fall into this category. Below is a summary of the historical exploration of alternative approaches, including using a predator consumption based mortality estimation approach.

ACL Approaches for Octopus in Alaska

OFL (t)	Method
2006 – 2010 Exploration of alternative methods	
324	Average of Historical Incidental Catch
688	Maximum of Historical Incidental Catch
2,053	Trawl Survey Biomass +Rikhter and Efanov Mortality
2011 First Year of Separate ACL for Complex	
528	Maximum of Historical Incidental Catch (BSAI)
1,273	Trawl Survey Biomass +Rikhter and Efanov Mortality (GOA)
2012 – 2013 Introduction of New Methods	
3,452	Consumption-Based Estimate (BSAI)
1,941	Trawl Survey Biomass +Rikhter and Efanov Mortality (GOA)
2015 ??	Octopus Mortality Rate from Tagging Study

ACL Approaches for Sharks in Alaska

OFL (t)	Method
2006 – 2010 Exploration of alternative methods	
1,005	Average of Historical Incidental Catch
2,985	Maximum of Historical Incidental Catch
8,575	Trawl Survey Biomass + Combined Mortality Estimate
2011 First Year of Separate ACL for Complex	
7,467	Tier 5 estimate for spiny dogfish in GOA
571	Average of historical catch for all other shark species in GOA
8,037	Combined ACL for shark complex in GOA
1,363	Maximum of Historical Incidental Catch for BSAI sharks

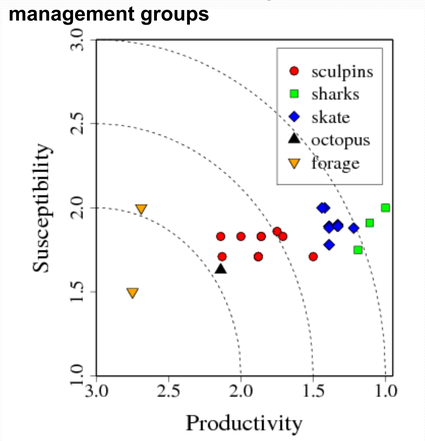


Potential overfishing limits (OFLs) for eastern Bering Sea octopus as calculated from survey catch and mortality estimates (blue bars), consumption-based mortality estimated from the measured diet and ration of Pacific cod (red bars), and from historical catch records (green line). Error bars show 95% confidence intervals for annual estimates. In 2012, the actual OFL approved by the Council was the geometric mean of the annual consumption-based estimates (3,500t).

Vulnerability analysis

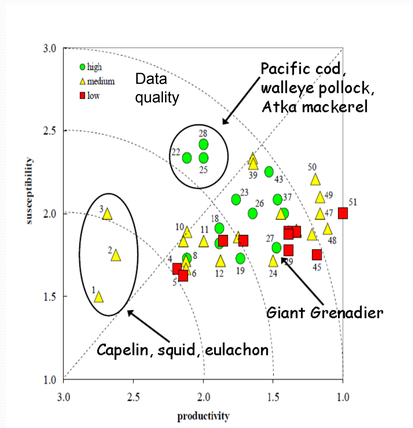
Part of the MSA 2006 ACL changes was a requirement for all fish stocks vulnerable to overfishing to have an ACL . A semi-quantitative approach was developed by NMFS to estimate the vulnerability of fish stocks to overfishing using a productivity-susceptibility analysis, originally created to evaluate bycatch issues in Australia. The PSA approach evaluates vulnerability as a function of productivity (based on attributes such as natural mortality, and age at 50% maturity) and susceptibility to fishing impacts, (based on attributes such as gear selectivity and spatial overlap with fisheries). This method was applied to NPFMC groundfish stocks to help inform decisions on species membership within stock complexes and also whether species should be classified as "in the fishery" or an "ecosystem component stock" or removed from the FMP altogether.

Vulnerability of some components of the BSAI "other fish" and forage fish management groups



The PSA analysis was a useful tool to provide information on separating the "Other" species group into complexes

Vulnerability of Bering Sea- Aleutian Islands (BSAI) Stocks



Decisions on designating stocks to be in the FMP (grenadier) or ecosystem component stocks (forage species) were aided by PSA.

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