# Stock assessment of elasmobranchs

*suitable approaches*
*for situations of limited data*

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## WHAT IS STOCK ASSESSMENT?

- **Stock assessment is the processes of collecting, analysing, and reporting fisheries and biological information for the purpose of determining the effects of fishing on fish populations**

Status + what is expected if…?

***A stock assessment provides decision makers with the information necessary to make reasoned choices.***

The mathematical and statistical techniques used to perform a stock assessment are referred to as the **assessment model**

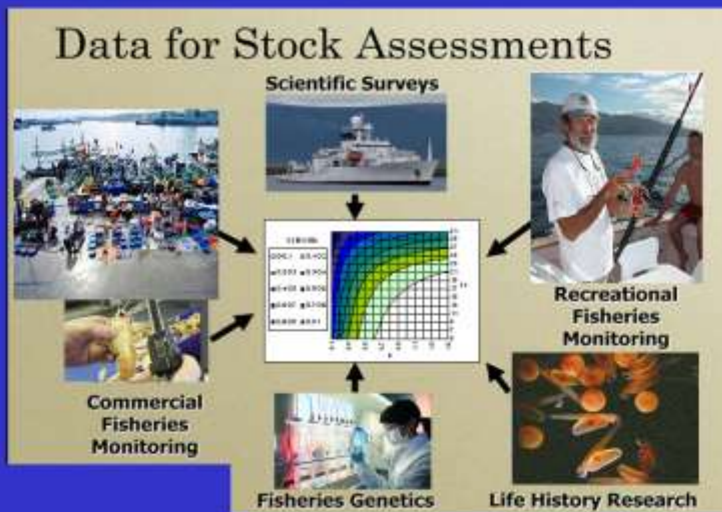
Scientists compare different assumptions within a given assessment model and may also examine a variety of different assessment models.

Ultimately, stock assessment scientists will estimate the current status of the stock relative to management targets and predict the future status of the stock given a range of management options.

They will also describe the most likely outcomes of those options and the uncertainty around those outcomes.

## STOCK ASSESSMENT FRAMEWORK

stock assessment process as a series of steps involving data collection, modeling/analysis and potential management actions based on the results of the stock assessment.

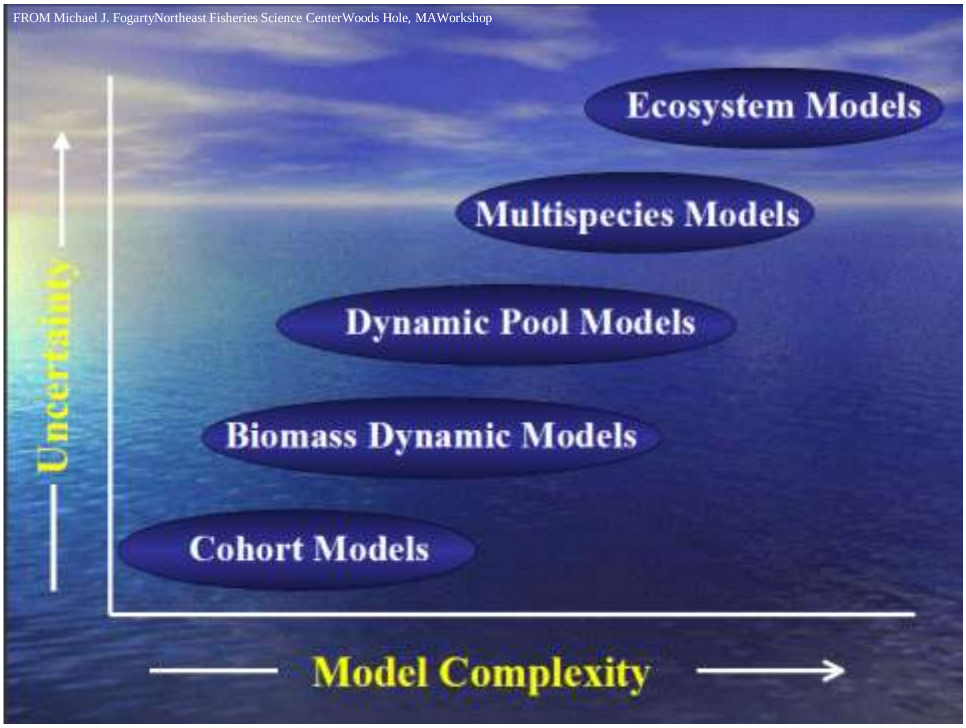



## WHAT MODEL TO USE?

**DATA AVAILABILITY**

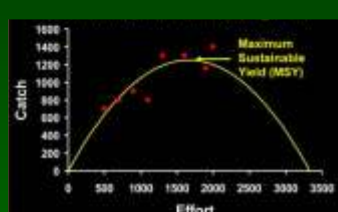
**MORE COMPLEX=MORE DATA NEEDED**

# DATA DRIVE MODELS




# MAXIMUM SUSTAINABLE YIELD

- GOAL…………..



# *Maximum sustainable yield*

**The World Summit on Sustainable Development,**

**Johannesbourg UN Conference goal:**

"…to maintain or restore depleted fish stocks to levels that can produce the maximum sustainable yield on an urgent basis and where possible by 2015"

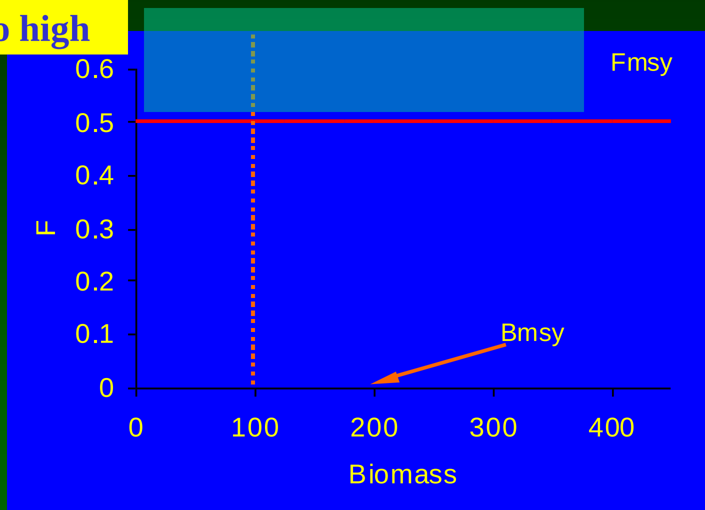
**Fishing at MSY** levels means catching the maximum proportion of a fish stock, that can **safely be removed** from the stock while, at the same time, **maintaining its capacity to produce maximum sustainable returns**, in the long term.

In the present system in most of the countries the focus of fisheries management was to avoid fish stocks falling to dangerously low quantities (i.e. using Limit RPs). **Now the focus is avoiding something bad seeking to achieve positive and useful improvements.**

MSY is based on the principle of **long-term management** which has been applied elsewhere, in particular in a huge number of recovery plans adopted or proposed for various stocks.

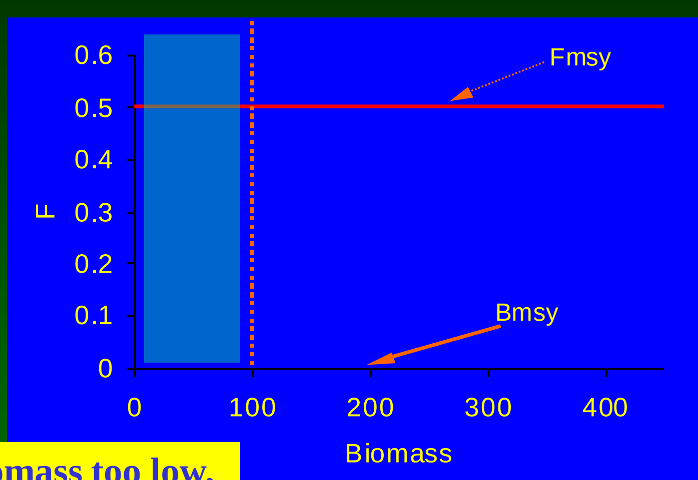
## When Overfishing Occurs?

**F too high**




(PRESURE)

## When a Stock is Overfished?




**biomass too low, below ½ Bmsy**

(STATUS)

STATE AND PRESSURE INDICATORS

| | $B < B_{threshold}$ | $B \geq B_{threshold}$ |
|---|---|---|
| $F \geq F_{threshold}$ | Stock is overfished & Overfishing is occuring | Stock is not overfished but Overfishing is occuring |
| $F < F_{threshold}$ | Stock is overfished but Overfishing is not occuring | Stock is not overfished & Overfishing is not occuring |

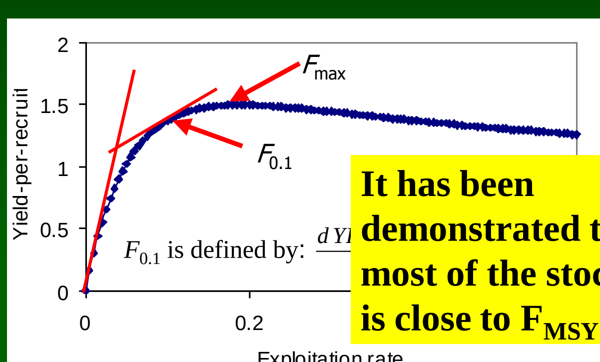
The need to address the Johannesbourg directives facing uncertainty

## In the case we are not able to estimate MSY or the level of F or B corresponding to MSY

**Kell and Fromentin, (2007) suggest using $F_{0.1}$ derived from Yield per Recruit analysis as an appropriate proxy of $F_{MSY}$ in case of data lacking or high uncertainty**

**State indicators of stock size in terms of biomass are more difficult to interpret through the observation of changes in biomass due to natural fluctuations, measurement errors, frequent lacking of long enough time series, etc.**

**F0.1:** The fishing mortality rate at which the increase in yield per recruit in weight for an increase in a unit of effort is 10 percent of the yield per recruit produced by the first unit of effort on the unexploited stock (i.e., the slope of the yield-per-recruit curve for the F0.1 rate is one-tenth the slope of the curve at its origin).




**It has been demonstrated that for most of the stocks $F_{0.1}$ is close to $F_{MSY}$**

## $F_{MBP}$ (F at Maximum Biological Production)

approach based on surplus production models, that avoid most of the problems of quality of commercial catch and demographic structure and usable with a limited amount of data

*MBP* is the comprehensive maximum production derived from the harvesting and from the biomass losses due to natural mortality

The Caddy and Csirke (1983) variant of Surplus Production models uses the instantaneous total mortality rate Z as a direct index of effort, and a catch rate (Kg/h) as abundance index

Potential use of trawl surveys data series of estimates of Z (with SURBA?) and Kg/km2 from swept area as abundance index.

## Why stock assessment?

- **The assessment of the exploitation status of a stock is necessary for ensuring sustainable production over time. It can be obtained :**
- **By regulating the fish removals,**
- **By allowing young fish to reproduce,**
- **By ensuring the implementation of these measures.**
- **Always keeping in mind the need of conservation and limitation of the environmental impact of fishing**

## What is overfishing?

- Removing too many fish
- Applying a too high fishing rate
- ***Result:***
- The stock cannot produce enough recruits to maintain itself at a productive level.

## Types of Overfishing

- **Growth overfishing- related to the size and age of fish**
- **Recruitment overfishing- related to the production of new recruits**

## Why does it matter?
**(overfishing)**

- **Causes the stock to decline to a less productive state**
- **Reduces future catches and earnings**
- **Removes fish too early in their life**
- **Reduces recruitment, in many cases dramatically**
- **Does not guarantee sustainabilty**

## REFERENCE POINTS

- **We don't need only to describe the current status as regards mortality rates, biomass, yields, surviving fraction of spawners, etc…**
- **…but to define if this is a desirable status or not**
- **…and also which management measures should be necessary to drive the stock to amore productive and safe status**

**Reference points: conventional values of the state of a fishery or a population that are considered the desirable objective to be reached (*target reference points*) or an undesirable state of the fishery which needs to be avoided (*threshold* or *limit reference points*).**

## *What are Biological Reference Points*

- *Key fishing rates or biomass levels that are related to the maximum potential of a stock*
- A ***fishing rate (F)*** that produce the highest catches or spawning potential
- A ***biomass*** level that produces the highest catches

# *Target*

*Management targets are:*

- *A level of F that gets you to a goal.*
- An F target gets you to a desired place (i.e.maximum yields, max.revenues,etc)

- *A level of biomass is a goal.*
- A biomass target is a desired place (i.e. a biomass level that represents some fraction of the pristine biomass)

# ***Limits***

***Limits are:***

- **F's you shouldn't exceed, a biomass you shouldn't go below**
- **A key reference point value like $F_{msy}$, $F\%_{SSBv}$ or $B_{msy}$**

## Methods for finding values of Reference Points

- **Surplus production models fmsy, Fmsy, Bmsy, etc**
- **Analytical models Fmsy, Fmax, F0.1, Frep, Fpa, etc**
- **Use of defined values of indicators as RPs**

## Methods

### Surplus Production models (SPM)

- **Excellent cost/benefit ratio**
- **Data requirements modest**
- **SPM can yield critical information for assessment and management:**
- **$B_o$,$B_{curr}$, level of depletion of the population, MSY, $f_{MSY}$**
- **Projections under different scenarios (yield, effort), and to evaluate outcomes of each scenario**

•Surplus Production models (SPM)

- but….
- They do not include stock structure and its changes
- They do not incorporate time delays (very important for elasmobranchs)
- Traditional versions assume equilibrium
- Need of contrast in levels of fishing pressure along time series

## •Yield per Recruit

- Simple approach
- Does not require time series
- It tell us if we are exploiting fish at the right age/size and with the right intensity
- Are easy to translate into direct management recommendations (changes in mesh size or regulation of fishing effort)

•Yield per Recruit

- **But…**
- **Assume equilibrium**
- **Not dynamic (no time variable)**
- **Do not incorporate density-dependent processes like S/R relationships**
- **Assume constant growth and mortality**
- **It may predict unrealistic yields at infinite effort**
- **The real magnitude of catch cannot be known**

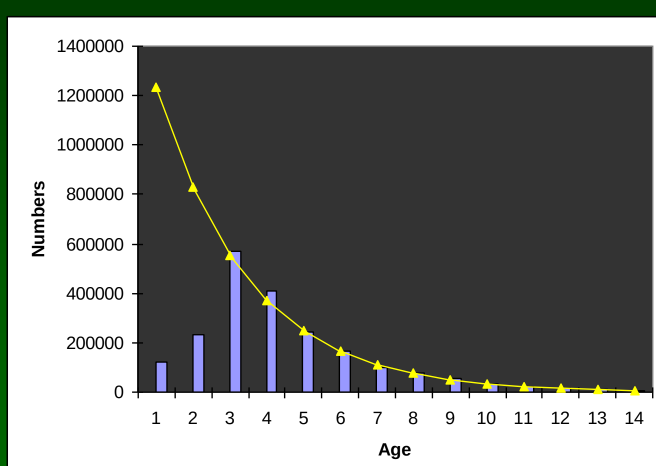
# How to estimate mortality

- Total mortality?
- Natural mortality?
- Fishing mortality?

# Z

- Catch curves
- B&H Equation and variants
- SURBA using scientific cruises data
- others

# Catch curves assumptions



## Beverton & Holt estimator

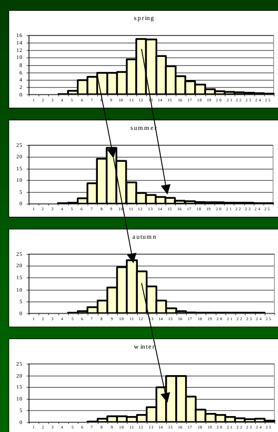
$$Z = K \frac{(L\infty - \bar{L})}{(L\infty - L')}$$

## Beverton & Holt estimator

$$Z = K \frac{(L\infty - \bar{L})}{(L\infty - L')}$$

- **Very strong assumptions**
- **Variant of Gedamke and Hoenig not assuming equilibrium**

## Using data from scientific cruises (SURBA and others)




## M

- Based on age structure of unexploited populations
- tagging experiments
- Empirical equations
- Z vs effort
- By analogies with other stocks

# F

- Z-F
- Analytical procedures
- Non-equilibrium Production models

# VPA and related approaches

- Very powerful approaches based in the analysis of the age or size structure of the commercial catches, often through retrospective analysis

## VPA family of methods
but….

- **quality of data as the more critical issue in chondrichtyan stocks.**
- **Data representing the real catches at age/size of the stock (under-reporting or species misidentification)**
- **Good reconstruction of demographic structure of the catch in several years in order to avoid wrong results.**

## Length cohort analysis

- VIT (Lleonart and Salat , 1997). (also with a pseudocohort)
- A version developed by IFREMER allows corrections in the variation in effort and recruitment (Laurec and Santarelli-Chaurand, 1986).

## Surplus production models

- They allow estimation of F by year as they estimate q
- Data issues
- Detection of changes in q

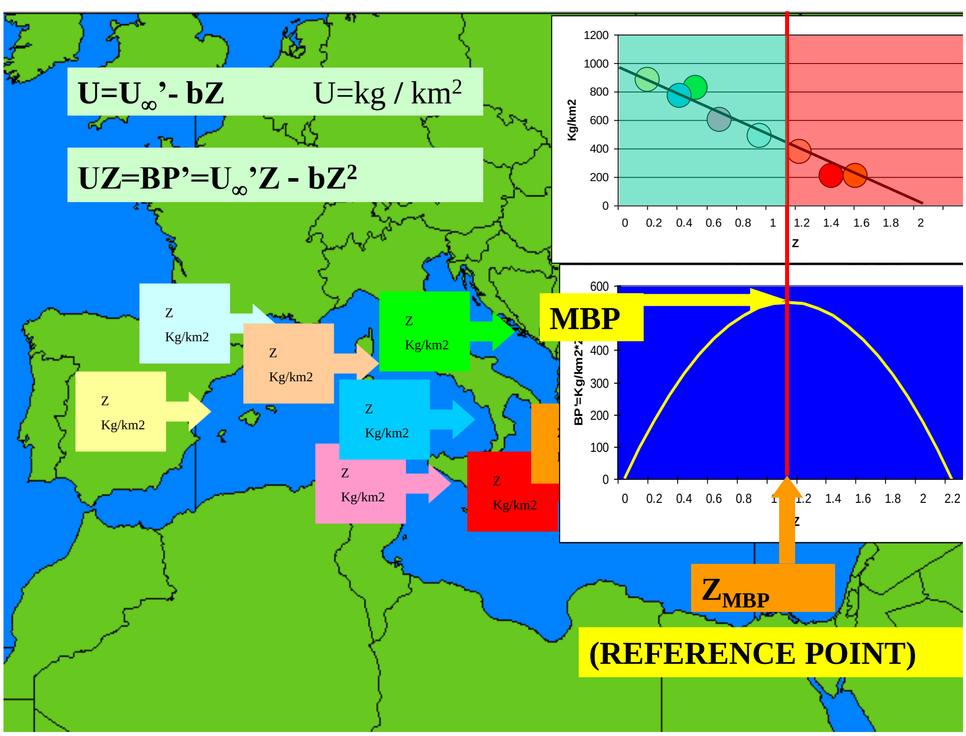
## Some attempts of stock assessement with limited available data

- Surplus Production models
- **Composite model**

- Composite models use spatial information proceeding from sub-areas exploited at different rates
- similar productivity and evolution under different levels of fishing pressure are assumed
- The change from a time to space-based data set allows the utilization of production models even in the case long data series on catch and effort are not available
- The results are not affected by most of the problems that characterize the traditional versions of surplus production models.

## Composite model

- The approach is used for the definition of a sustainable level of fishing pressure
- Also useful for a preliminary assessment of the current status of exploitation in different fishing grounds exploited with different rates
- In this case, total mortality rate is used as a direct index of fishing mortality
- Considering that Z includes both, removals of fishing activity and deaths due to natural causes, the model allows the estimation of the so-called Maximum Biological Production (MBP)



## Non equilibrium biomass dynamic Models

Traditional: Time series of index of abundance and effort

$$Bt+1 = Bt + rBt(1-(Bt / k)) - qfBt$$

With trawl surveys NO data on effort

As $qfBt = Y$, *catch in weight ($Y_t$) can be substituted by the classic Baranov (1918) catch equation*

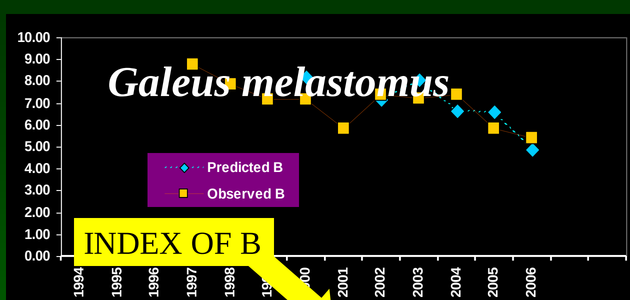
$$Y=(F/Z)\ B(1-exp(-Zt)$$

and then the following equation is obtained:

$$Bt+1 = Bt + rBt(1-(Bt / k)) – (F/Z)\ Bt(1-exp(-Zt)\ )$$

Non equilibrium surplus production model

$$Bt+1 = Bt + rBt(1-(Bt / k)) – (F/Z)\ Bt(1-exp(-Zt)\ )$$




| Time | Observed Z | Predicted B | Observed |
|---|---|---|---|
| 1994 | | | [illegible] |
| 1995 | | | [illegible] |
| 1996 | | | [illegible] |
| 1997 | | | [illegible] |
| 1998 | | | 7.85 |
| 1999 | 0.862 | | 7.14 |
| 2000 | 0.711 | 8.18 | 7.17 |
| 2001 | 0.836 | | 5.80 |
| 2002 | 1.185 | 7.14 | 7.36 |
| 2003 | 1.534 | 8.06 | 7.21 |
| 2004 | 1.56 | 6.64 | 7.35 |
| 2005 | 1.428 | 6.59 | 5.82 |
| 2006 | 0.928 | 4.88 | 5.38 |

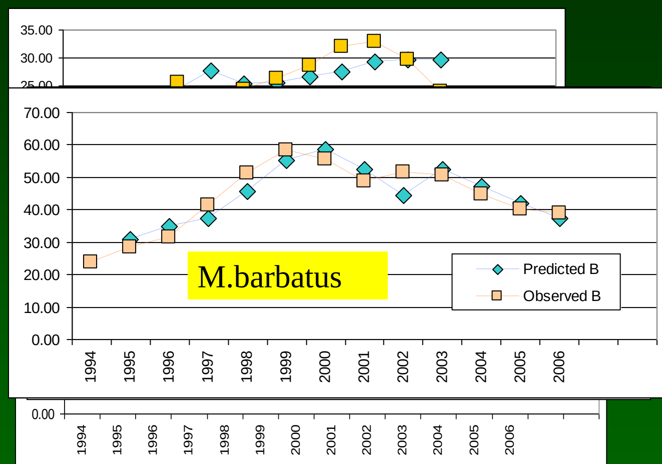
**MINIMIZATION OF RESIDUALS**

r=

FMSY=

**Need of contrast!!!**

Used for different stocks…




# Other attempt of stock assessement with available data

- **Yield per recruit**

**A Beverton & Holt like model can be constructed.**

- **Common biological parameters (considered representative for the species for the whole area) were used**
- **Y/R and S/R curves are defined**
- **$F_{max}$, $F_{0.1}$ and $F_{30\%SSB}$ are estimated**
- **$F_{curr}$ is compared with the above Reference Points**

## Life tables and Leslie matrices

- The approaches based on life history traits as fecundity and survival rates are widely used for modelling population dynamics in elasmobranchs
- SIMPLE
- MODEST DATA REQUIREMENTS

## AND MANY OTHERS…

- Stage-based assessment model Collie-Sissenwine Analysis model
- The Deriso (1980) delay-difference model (a combination of production models with age structured models)
- others…

## INDICATORS

- An indicator is a value that defines the state, response or development of important aspects of a species or group of species.

## INDICATORS

- SIZE BASED
- TRENDS IN ABUNDANCE
- REPRODUCTION-BASED
- CATCH/BIOMASS
- DEPLETION CORRECTED AVERAGE CATCH (DCAC)
- AN INDEX METHOD (AIM)
- OTHERS

# INDICATORS

- THE PROBLEM OF DEFINITION OF A REFERENCE POINT FOR THE INDICATORS
- (attempts of addressing this issue with AIM and DCAC)

## ECOSYSTEM CONSIDERATIONS

Interactions between species

Environmental influence

**Ecosystem effect**[illegible]*ate populations)*

| Indicator | Observation | Interpretation | Evaluation |
|---|---|---|---|
| *Prey availability* [illegible] | | | |
| Pollock | Increasing to steady population currently at a high biomass level | Adequate forage available for piscivorous skates | No concern |
| Atka mackerel | Cyclically varying population with [illegible] | Adequate forage available for [illegible] | No concern |
| Shrimp<br>Benthic invertebrates | Trends are not currently measured directly, only short time series of food habits data exist for potential retrospective measurement | Unknown | Unknown |
| *Predator population trends* | | | |
| Sperm whales | Populations recovering from whaling? | Possibly higher mortality on skates? But still a very small proportion of mortality | No concern |
| Steller sea lions | Declined from 1960's, low but level recently | Lower mortality on skates? | No concern |
| Sharks | Population trends unknown | Unknown | Unknown |
| *Changes in habitat quality* | | | |
| Benthic ranging from shallow shelf to deep slope, isolated nursery areas in specific locations | Skate habitat is only beginning to be described in detail. Adults appear adaptable and mobile in response to habitat changes. Eggs are limited to isolated nursery grounds and juveniles use different habitats than adults. Changes in these habitats have not been monitored historically, so assessments of habitat quality and its trends are not currently available. | Continue study on small nursery areas to evaluate importance to population production | Possible concern if nursery grounds are disturbed or degraded |

**Groundfish fishery effects on ecosystem via skate bycatch** ***(evaluating level of concern for ecosystem)***

| Indicator | Observation | Interpretation | Evaluation |
|---|---|---|---|
| *Fishery contribution to bycatch* | | | |
| Skate catch | Varies from 12,000 to 20,000 tons annually | Largest portion of total mortality for skates | Possible concern |
| Forage availability | Skates have few predators, and skates are small proportion of diets for their predators | Fishery removal of skates has a small effect on predators | Probably no concern |
| *Fishery concentration in space and time* | Skate bycatch is spread throughout FMP areas | Potential impact to skate populations if fishery disturbs nursery or other important habitat; but small effect on skate predators | Possible concern for skates, probably no concern for skate predators |
| *Fishery effects on amount of large size target fish* | Size of bycaught skates not measured | Unknown | Unknown |
| *Fishery contribution to discards and offal production* | Skate discard a relatively high proportion of skate catch, some incidentally caught skates are retained and processed | Unclear whether discard of skates has ecosystem effect | Unknown |
| *Fishery effects on age-at-maturity and fecundity* | Skate age at maturity and fecundity are just now being described; fishery effects on them difficult to determine due to lack of unfished population to compare with | Unknown | Unknown |