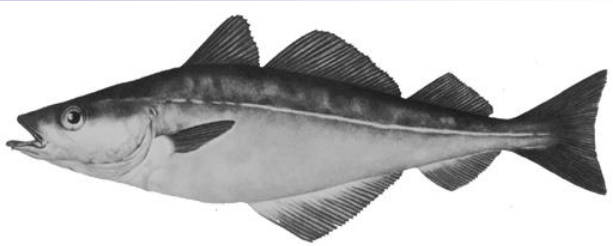


A Management Strategy Evaluation for the Canadian Pollock Fishery off Southwestern Nova Scotia

H.H. Stone (DFO Canada)

D. S. Butterworth and R.A. Rademeyer

(University of Cape Town, South Africa)

Background

- Pollock (*Pollachius virens*) are found on both sides of the North Atlantic; life history involves an offshore spawning and larval phase, recruitment to the coastal environment for 1-2 years, followed by an offshore migration

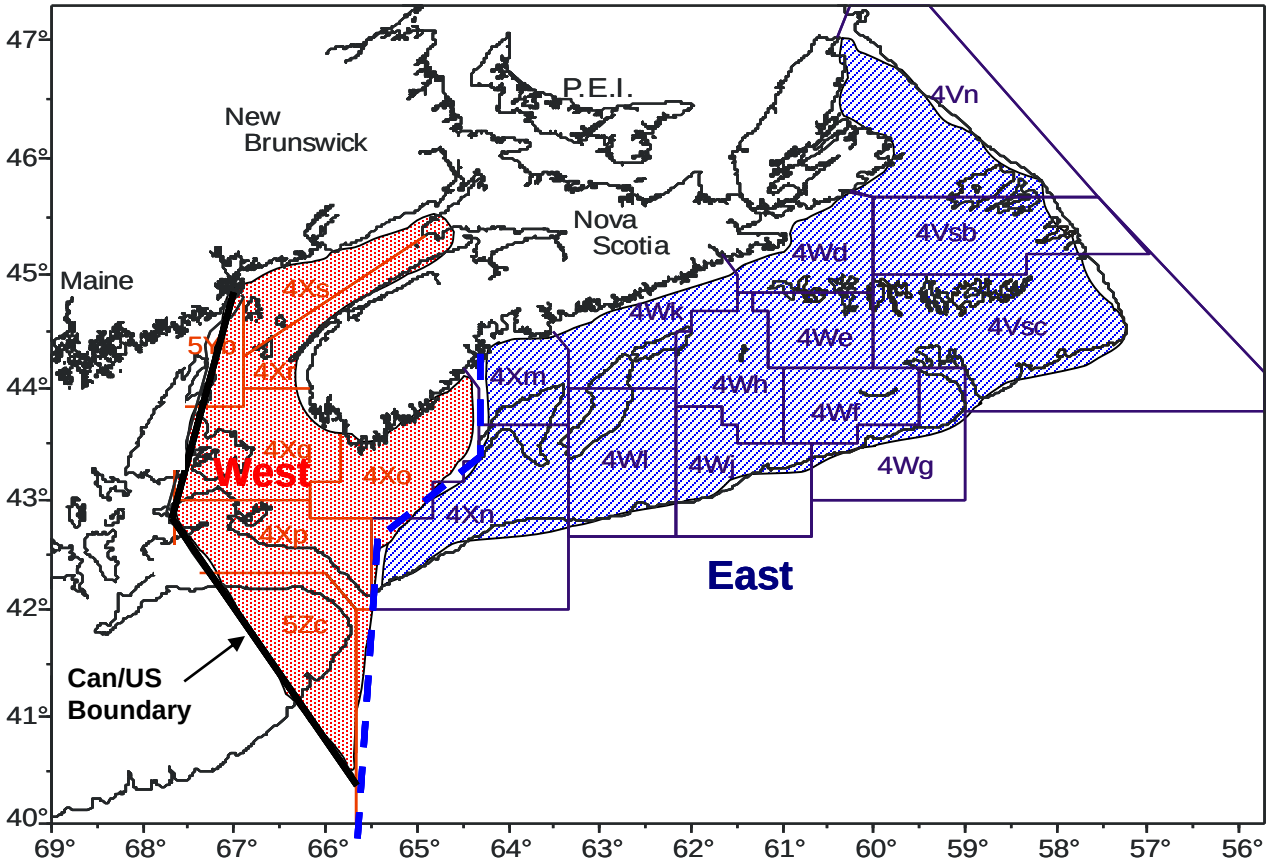
- Important CDN fisheries occur on the Scotian Shelf, eastern Georges Bank and in the Bay of Fundy using primarily otter trawls and gillnets

- Exhibit strong schooling behaviour and spend less time on the bottom and more time moving freely through the water column than other gadids

- Since they are a semi-pelagic schooling species, the main bottom trawl survey index used to tune Virtual Population Analysis model (traditional assessment approach) has high inter-annual variability

- Relationship between the **Survey Biomass Index** and underlying **population abundance** **may not be proportional**

CDN Pollock Management Unit (NAFO Div. 4VWX5)



- Assessed separately as two population components: a faster growing **Western component** and a slower growing **Eastern component**
- Western Component has been main focus of past analytical assessments but scientific advice on stock status and catch limits using VPA modelling has been highly variable, especially since mid-2000s

MSE Approach

- CDN fishing industry recommended exploration of alternative approaches which would provide more stability in future catch limits, allow better business planning and a more stable fishery

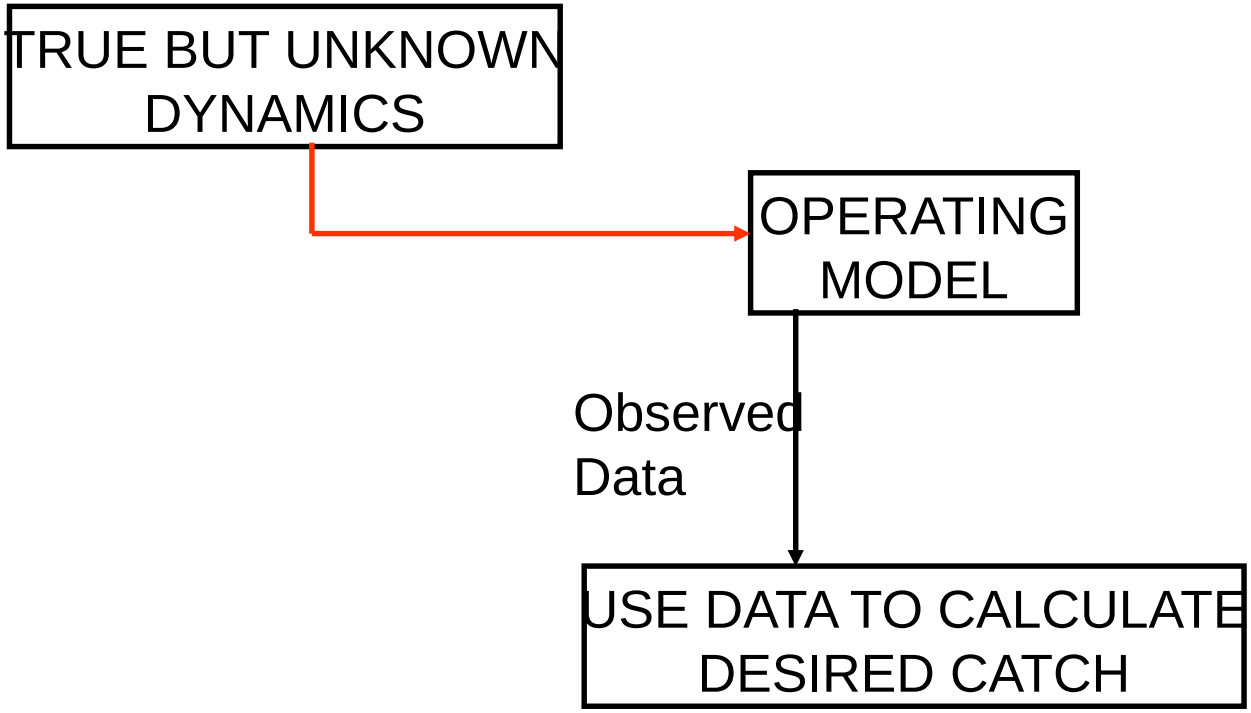
- In 2011, CDN fisheries managers and industry decided to manage pollock in the Western Component by means of a risk management approach, specifically using **Management Strategy Evaluation (MSE)** *(first time for CDN Maritimes Region)*

- This is a technique to explicitly consider the uncertainty in stock assessment assumptions and models, and to compare the likely consequences for Management Objectives when a predetermined **Management Procedure (MP)** incorporating a **Harvest Control Rule (HCR)** is applied

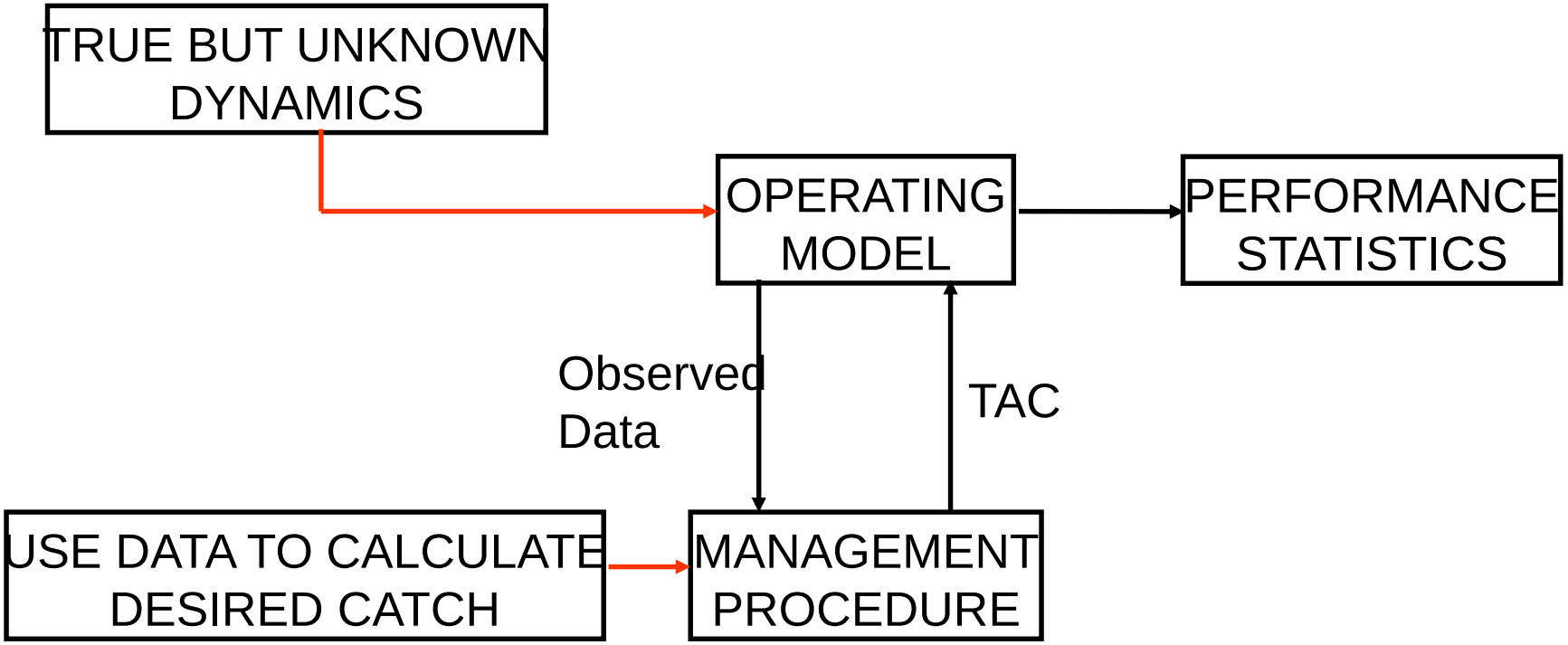
- Changes focus from a traditional ***"best assessment"*** (single stock assessment advice) to identifying a ***"best procedure"*** where best implies the procedure that most closely meets the desired management objectives over a range of plausible assessments

Outline of MSE Approach

COMPUTATION STRUCTURE



Outline of MSE Approach



- Uncertainties reflected by different operating models for "reality"
- Management procedure must produce satisfactory performance across a range of plausible operating models

Objectives for Management

- High catch in short and longer term
- Small chance of unintended reduction and/or inadequate recovery
- Small changes in catch from year to year

Conflicting → Trade-offs

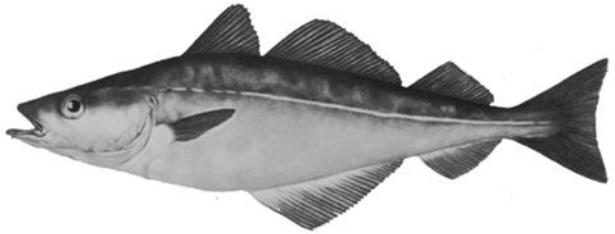
Aim

Find a management procedure which:

- Provides desired trade-offs
- Is (through feedback) reasonably robust in achieving this performance for alternative operating models with different underlying dynamics

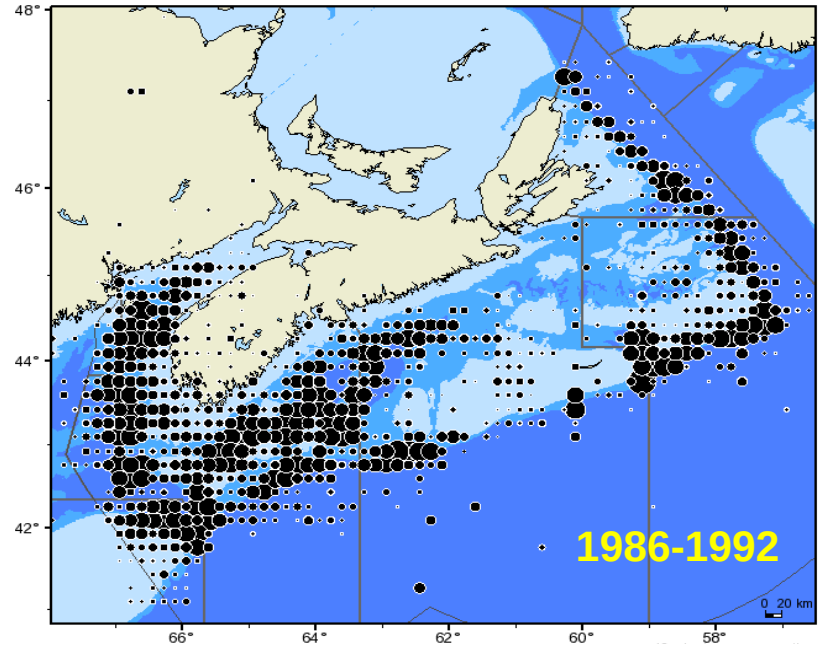
How it works

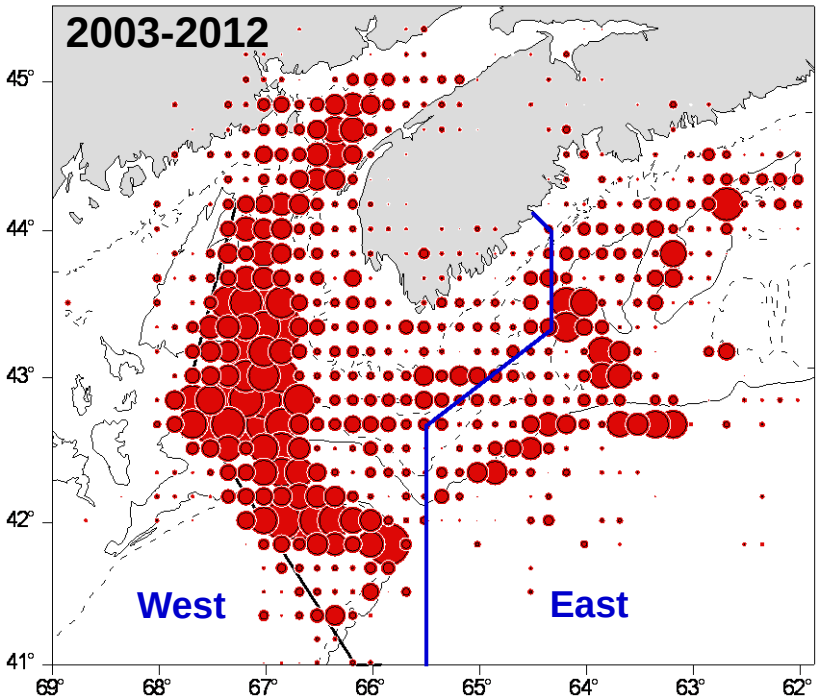
- Operating model "OM"
  - Provided by alternate assessments
  - Split into Reference Case ("best assessment") and robustness tests
  - Sometimes integrate over Reference Set to include 2-3 major uncertainties
- Management procedure "MP"
  - From simple population model fit and control rule
  - Empirical (e.g. adjust TAC based on trends in abundance indices)



Commercial Fishery

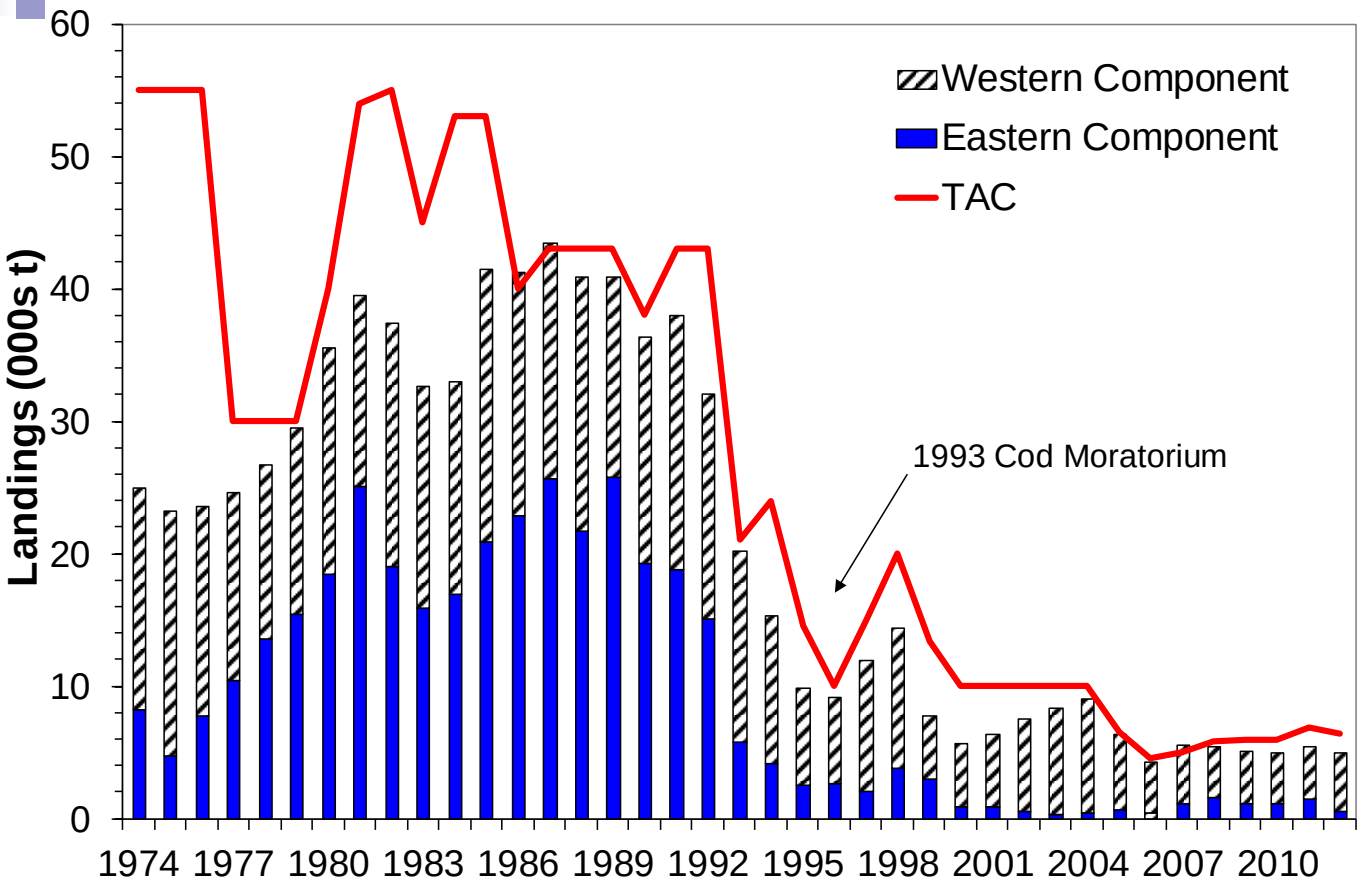
CDN Pollock Fishery: 1986-1992 vs 2003-2012



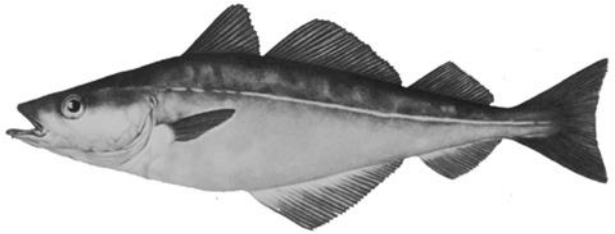


- During 1980s and early 1990s there was a significant CDN fishery for pollock on Eastern and Western Scotian Shelf with catches taken mainly by large otter trawlers (> 65')
- In 1993, Eastern SS was closed to cod and haddock directed fishing which reduced pollock landings from that area
- WC: catches now occur mainly in Crowell/Jordan Basins, outer BoF, NE Georges Bank
- EC: along shelf slope, around La Have Bank and Emerald Basin

Fishing Year Landings (April 1-March 31) and Quotas

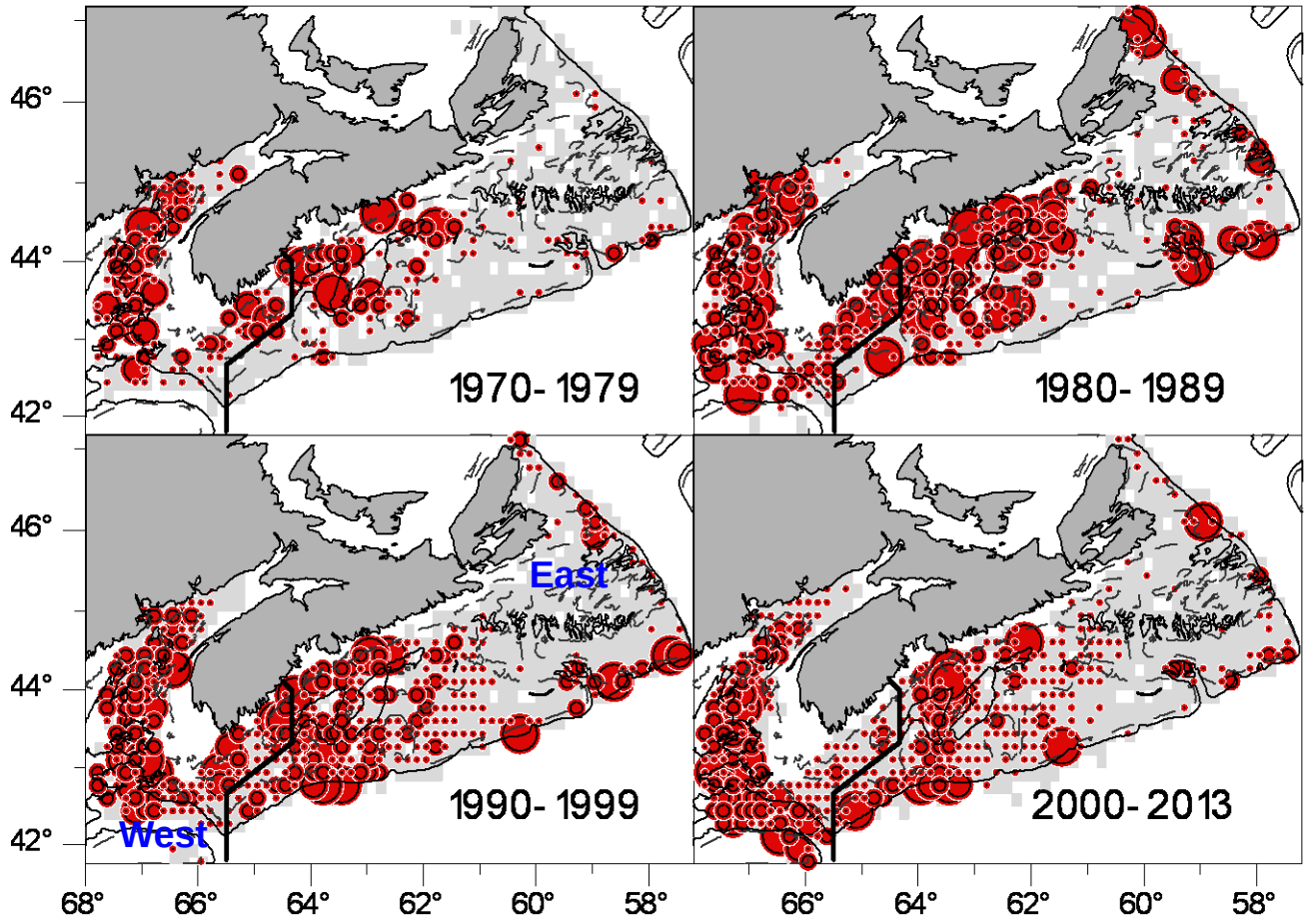


- ***EC*** landings dominated catches in the 1980s but declined after 1993 when the Eastern SS was closed; FY landings were 1,400 t in 2011/12 and 500 t for 2012/13 **(TAC = 1,600 t)**
- Since 1993, ***WC*** accounts about 80% of total landings which were 4,400 t in 2011/12 and 2012/13 **(TAC = 4,800 t)**
- **Catches generally < TAC**



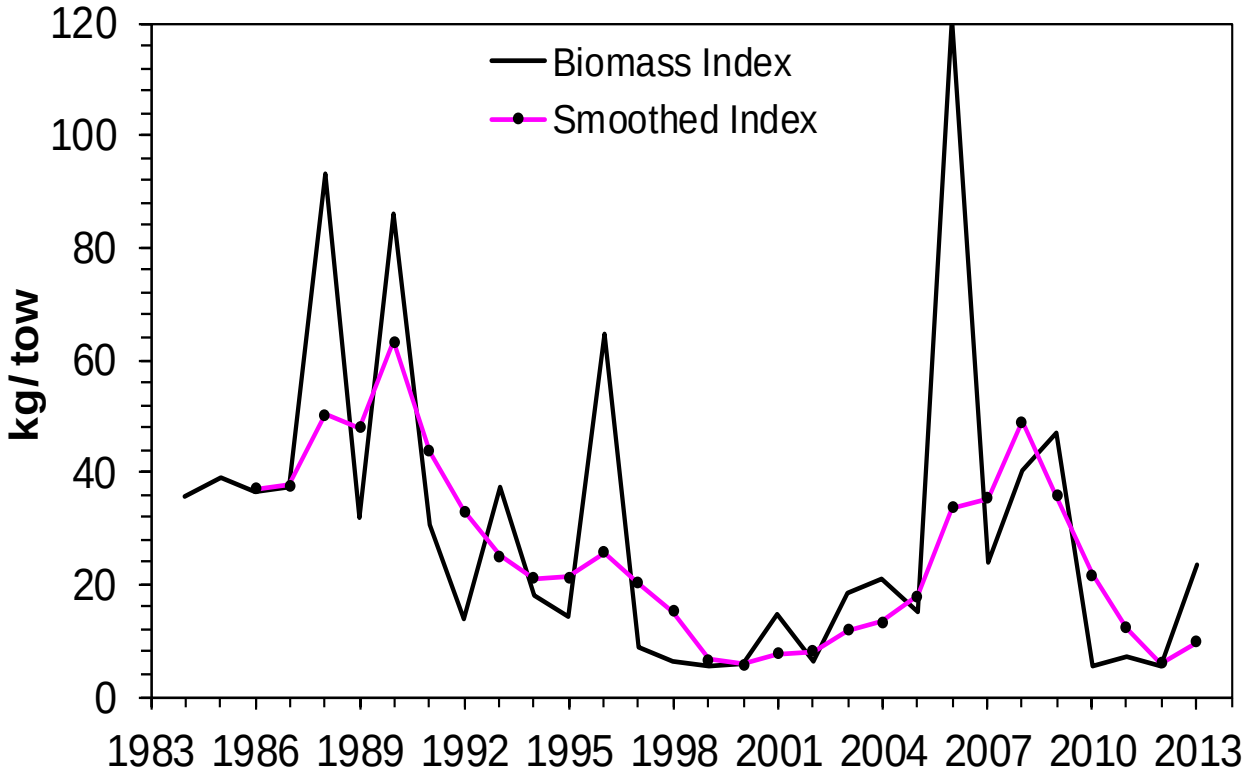
DFO Summer Survey

DFO Summer Survey: Pollock Biomass Distribution



- DFO has conducted annual summer bottom trawl surveys of the Scotian Shelf/Bay of Fundy region since 1970
- Main areas of pollock abundance have always been in central & western SS region; in the 1980s there was an expansion in distribution to the eastern shelf followed by contraction to the western area in the 2000s

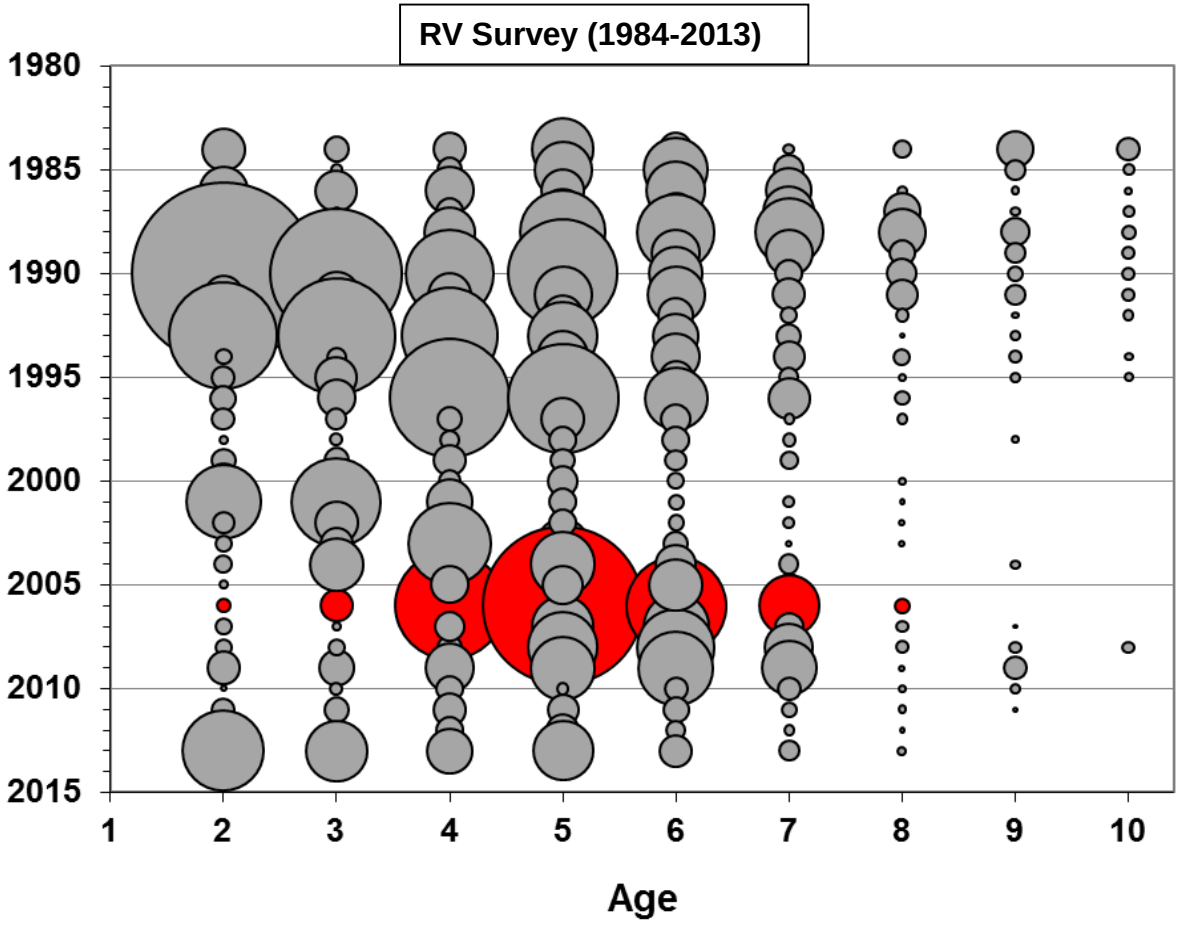
DFO Summer Survey Biomass Index, Western Component (1984-2013)



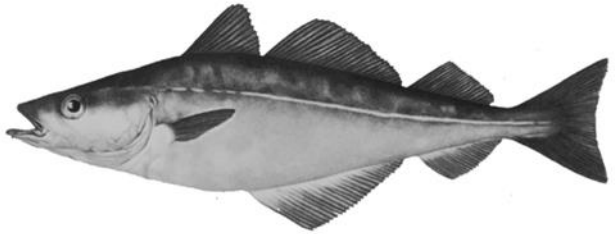
Smoothed RV series using *ln* transformed 3-yr moving average gives a better impression of long term trends by removing year effects and provides the monitoring data used in the Harvest Control Rule for calculating future catch limits

- Strong year-effects reflect the semi-pelagic schooling behaviour of pollock and changes in availability to gear
- Declining trend in index since the late 1980s, an increasing trend from 2003-2007, followed by another decline to 2012
- *Although index is highly variable, the long term trends are important*

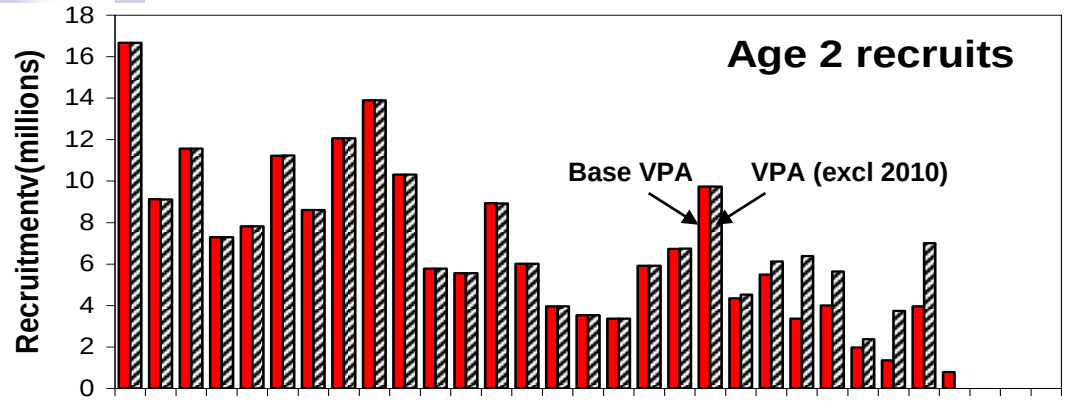
RV Survey Age-Specific Indices (Ages 2-10)

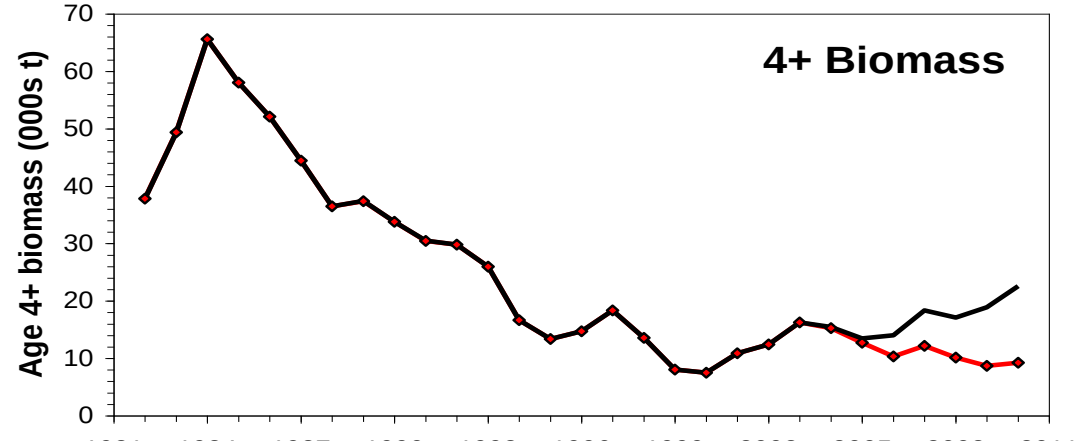


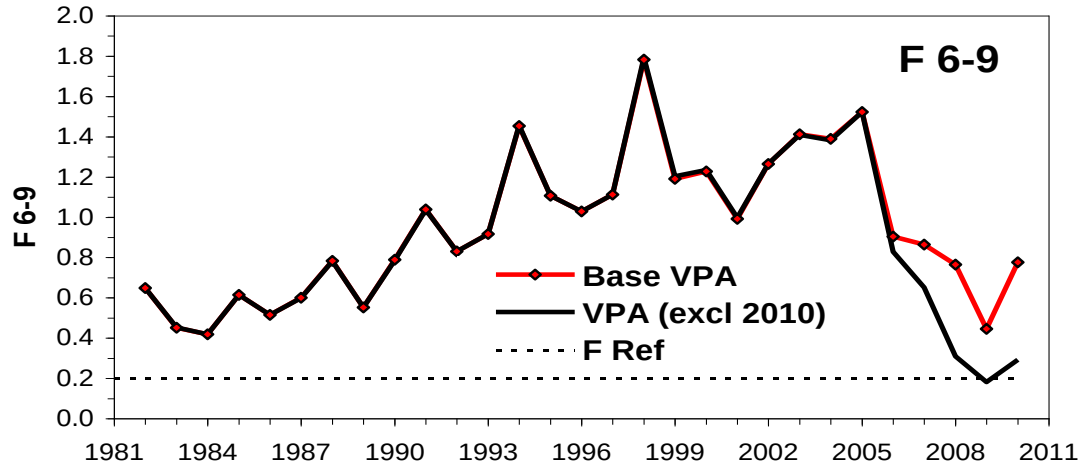
- RV survey indices monitored for changes in age structure which could trigger an exceptional circumstance (i.e. when extremely compressed/expanded)
- Period of diminished numbers at age for older ages from 1995-2005, with some modest improvement since then, not many older fish beyond age 7
- Strong year effect in 2006 RV indices (**red bubbles**)



MSE Approach







2010 Assessment and Sources of Uncertainty

- When assessment was last updated in 2010, there were substantial differences in the estimates of Age 2 recruits, age 4+ B and age 6-9 F, depending on whether the very low 2010 RV indices were included/excluded from the analysis

- Illustrates one of major sources of uncertainty in the pollock assessment arising from high variability in survey indices, but there are also several other sources of uncertainty

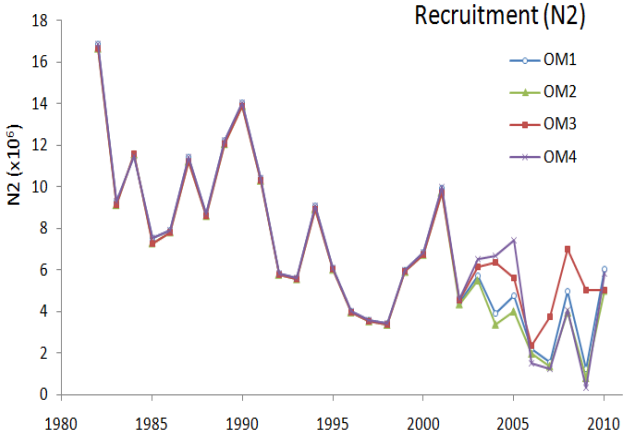
How do you deal with these problems in order to provide consistent and meaningful scientific advice?

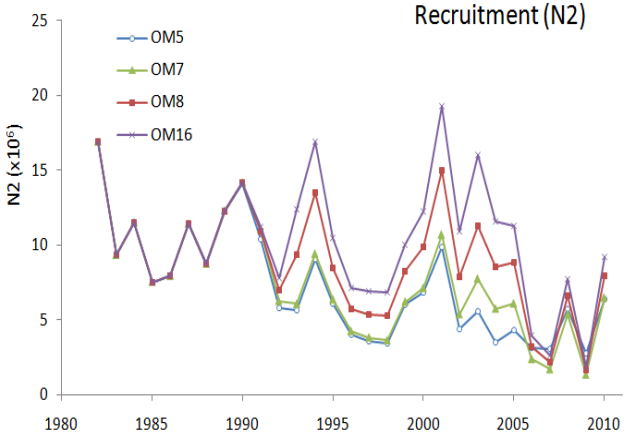
MSE Operating Models

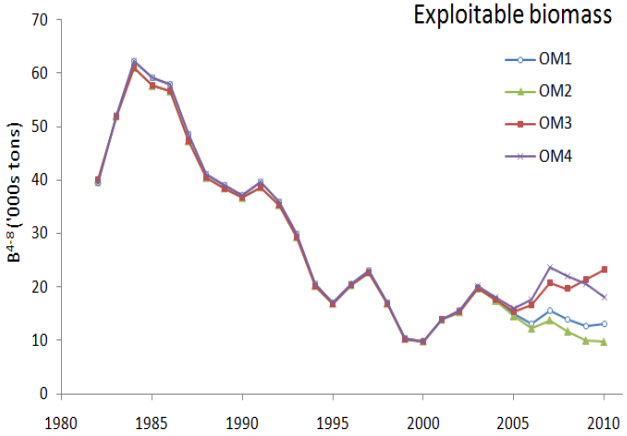
Rather than developing a “best assessment” VPA model with assumptions about key uncertainties about WC pollock, a series of 17 VPA type Operating Models were developed to cover the full plausible range of uncertainties:

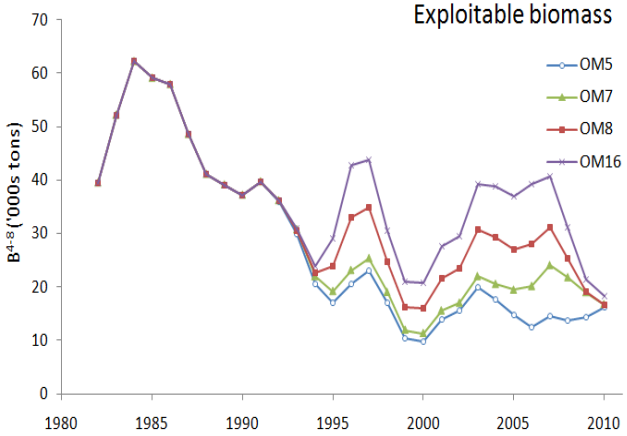
- Variability in RV survey
- Changes in natural mortality (M)
- Partial recruitment on older ages
- High variability in recruitment
- Stock-Recruit relationship

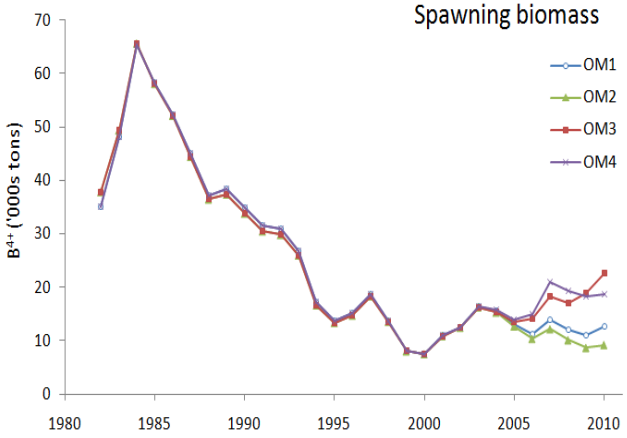
A subset of 6 was chosen as a balanced **Reference Set** against which various Candidate Management Procedures were simulation tested

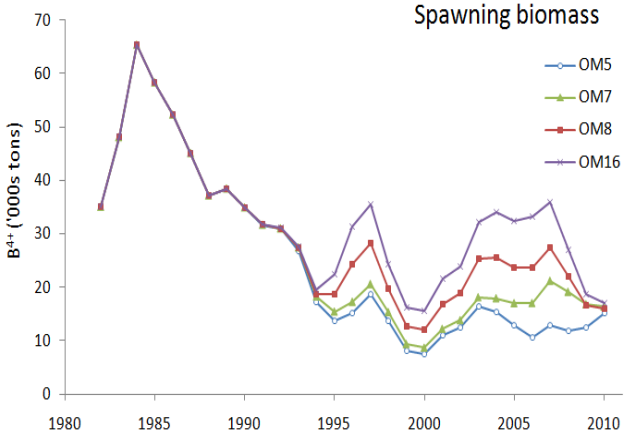












Operating Models

- Illustration of trajectories for recruitment, exploitable biomass and spawning biomass for 8 of 17 operating models
- Capture the full range of uncertainties in the pollock assessment (i.e. from optimistic to pessimistic)
- Simulation testing of MP assumes future variability levels will be as in the past, but note that behaviour could change in future

Medium Term Management Objectives

Medium Term (10-yr) Management Objectives for WC pollock agreed to by industry and fisheries management:

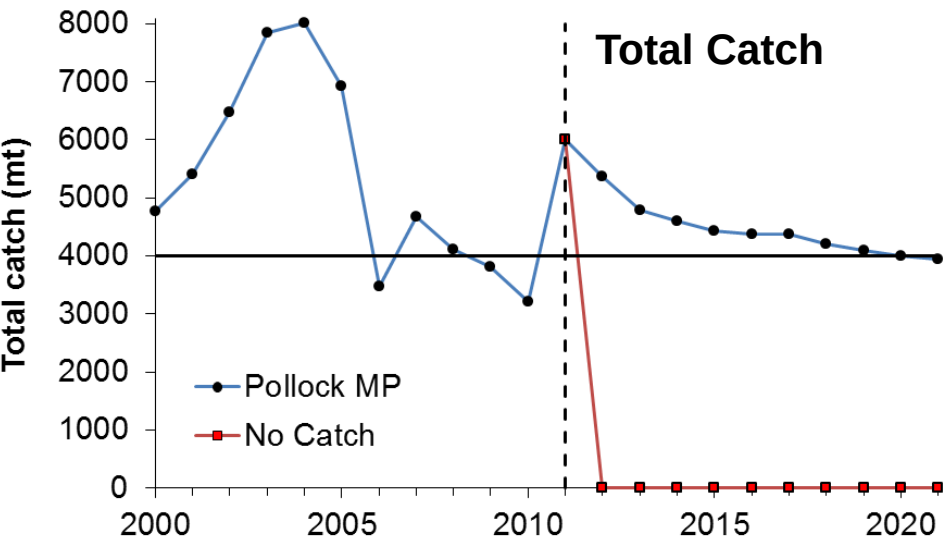
1. ***Sustainability:*** achieve exploitable (B^{4-8}) biomass in 2021 at a level 1.5 times B^{4-8} in 2000 (low point in VPA time series from which recovery occurred)

2. ***Catch:*** must be greater than 4,000 t/yr over next 5 years, starting in 2012

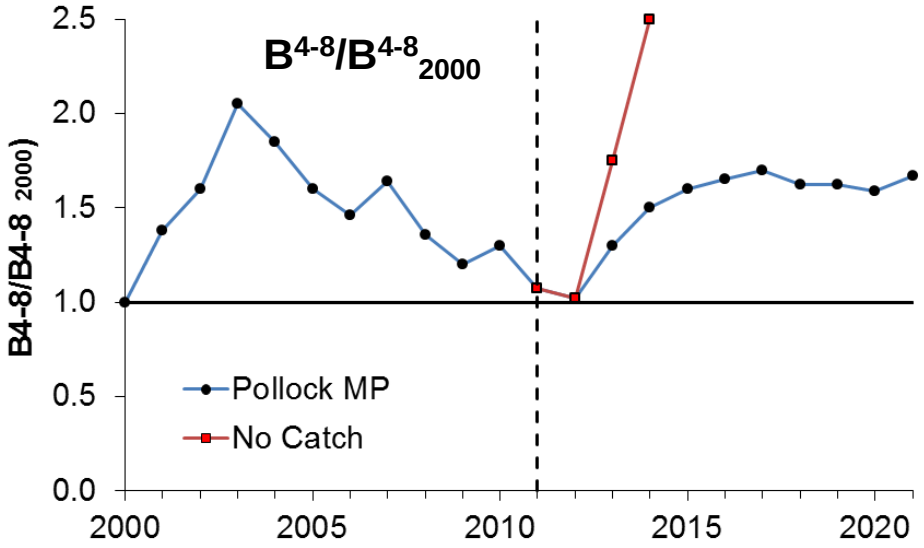
3. ***Restrictions on annual catch changes and maximum catch:*** maximum inter-annual catch increase of 20% or 500 t, whichever is greater; maximum inter-annual catch decrease of 20% (could *be greater depending on survey results)*

A Management Procedure was selected which satisfied these three different objectives, and traded off the level of catch in the medium term against the extent of resource recovery

Trajectories for Future Catch and Exploitable Biomass: Pollock MP vs No Catch Scenarios

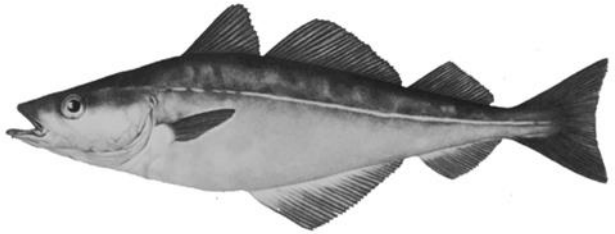


Median catch trajectories for "Pollock MP" and "No Catch" scenarios



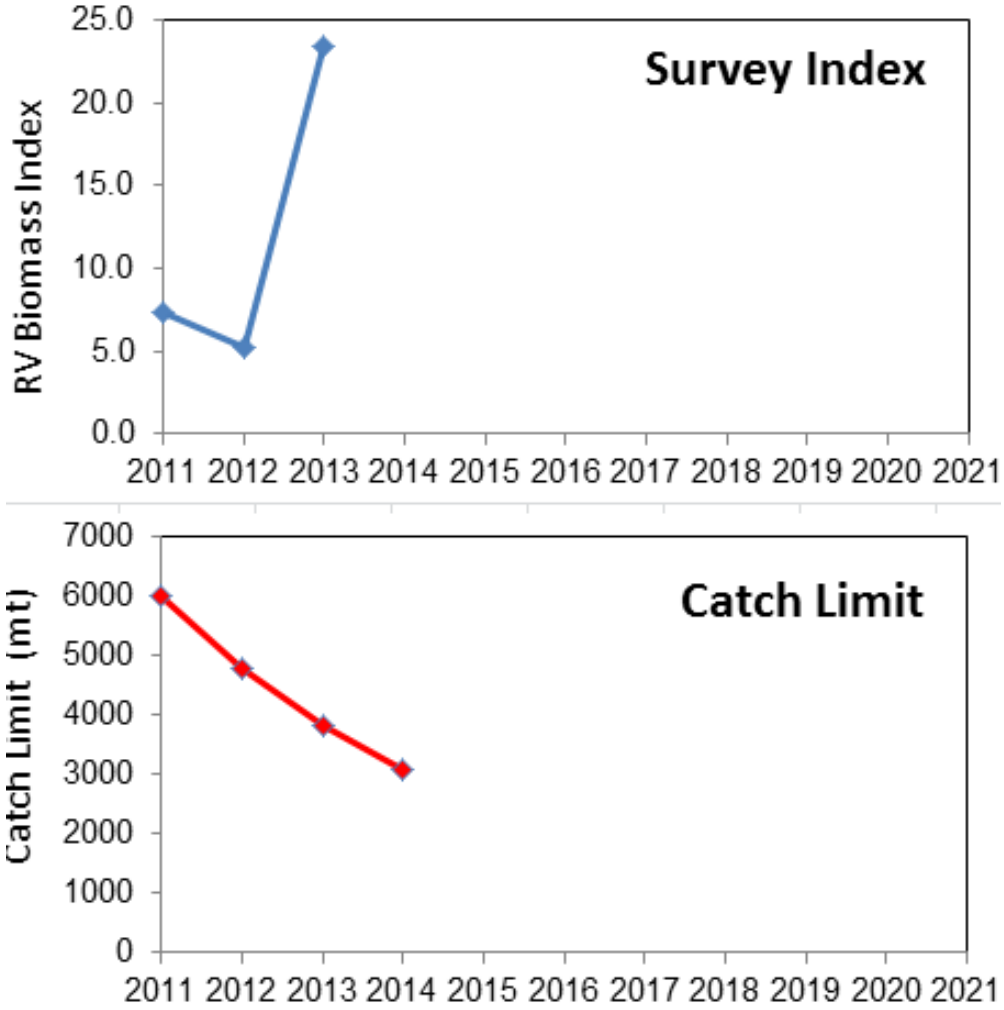
Median exploitable biomass trajectories (relative to 2000 level) for the "Pollock MP" and "No Catch" scenarios

- The values of the Pollock MP median curve for total catch over 2012 to 2016 show that the catch-related Management Objective of values above 4000 t are met for that period
- Pollock MP curves in the right plot show that in 2021 the sustainability related management objective for exploitable biomass was met



Harvest Control Rule

Catch Limit for 2014/15 Fishing Year



- Catch limit was initially set at 6,000 t in 2011 for the Management Procedure Model
- RV survey biomass index for pollock was low in 2011 and 2012 but increased in 2013
- HCR calculates a catch limit of 3,072 t for the Western Component in FY 2014/15
- HCR has responded to declining survey index values in 2011 and 2012

Exceptional Circumstances

- Protocols/rules to cover situations outside the range for which the Management Procedure model was simulation tested
- Could be applied to amend catch limits set by the MP or to revise the MP itself (it should not be a frequent occurrence – hopefully no more than once per decade!)
- Based on unexpected results (up or down) from monitoring data (i.e. RV survey biomass index)

Results that would trigger an EC:

- **When RV survey index ratio (J_y) falls below 0.2 or is outside 90% probability interval from model predictions**

  *Current survey index ratio (based on GM survey index for 2011-2013) is **0.27** which is above the exceptional circumstance value of **0.2***

- **When RV survey biomass index is < 6.0 kg/tow for two consecutive years**

  2013 RV index was 23.45 kg/tow; 2012: 5.28 kg/tow, 2011: 7.31 kg/tow; not an exceptional circumstance

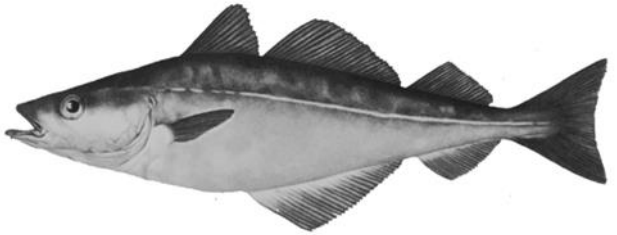
Actions Taken if Exceptional Circumstance Occurs

1. Review information, but maintain the Management Procedure as the management mechanism - additional research/monitoring may be recommended to determine if the signal detected warrants moving to step 2;

2. Advance the review period and revise the Management Procedure, but implement the Management Procedure outputs;

3. Set a catch limit that departs from the Management Procedure, and revise the Management Procedure

Conclusions and Future Steps



- MP with it's HCR are responding to declining trends in survey biomass index for WC pollock by bringing catch limits down

- Unless an Exceptional Circumstance is triggered, application of the Management Procedure will provide the catch limit for WC pollock until 2016, after which there will be a thorough review, including re-evaluation of the Reference Set of Operating Models to ensure they reflect current stock dynamics
- At that time we can address questions like "do we want more recovery?" or "do we want to invest more of the growth back into the biomass of the population?"
- Management Objectives will again be reviewed, in particular the trade-offs between catch and sustainability; can also incorporate any new information on stock dynamics at this time