MSE: MANAGEMENT STRATEGY EVALUATION

OR

THE MANAGEMENT PROCEDURE (MP) APPROACH

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OUTLINE

I. Best assessment based management

II. Management Procedures (MSE)
   - Feedback control
   - What exactly is an MP?
   - Computational structure

III. Example: South African hake MPs

IV. Some features of MPs
I. BEST-ASSESSMENT-BASED MANAGEMENT

E.g. US Magnuson-Stevens Act with its MSY-related recovery targets

“Best Assessment” of resource

Catch control law

TAC
DIFFICULTIES FOR THE BEST-ASSESSMENT-BASED APPROACH

- Inter-annual best assessment/TAC variation (including MSY-related Reference points)
- No consideration of longer term trade-offs (which requires taking account of management responses to future resource monitoring data)
- Lengthy haggling
- What if the “best assessment” is wrong?
- Default decision of “no change”
BUT WHY IS FISHERIES MANAGEMENT SO DIFFICULT?

SUSTAINABLE UTILISATION

- Pensioner must live off interest
- What’s my capital?
- What’s the interest rate?
- Multiply the two
- Don’t spend more than that!

EASY!!
THE SOURCE OF THE DIFFICULTY

FISHERIES HAVE UNCO-OPERATIVE BANK TELLERS

- They won’t tell you the interest rate, which in any case is highly variable

  Recruitment fluctuations

- They will advise your balance only once a year, with a typically +50% error, and in the wrong currency

  Surveys are typically annual only, results have high variance, and bias unknown
II. MANAGEMENT PROCEDURES (MSE)

WHAT NEW DO THEY BRING TO ASSIST SOLVE THE PROBLEM?

FEEDBACK CONTROL!

Monitor stock changes and adjust management measures (e.g. TACs) accordingly.
A FINANCIAL ANALOGY

$1,000,000 invested at 5% p.a.
Each year withdraw $50,000 ⇒
Investment sustainably maintained at $1,000,000

1,000,000 ton fish stock grows naturally at 5% p.a.
Each year catch 50,000 tons ⇒
Sustainable exploitation: resource kept at 1,000,000 tons
After 5 years, someone **MAY** have stolen $300,000 from your investment.

You keep withdrawing $50,000 per year.

After 5 years, recruitment failure or IUU fishing **MAY** have reduced abundance by 30%.

Catches maintained at 50,000 tons per year.

If this event did occur, resource is rapidly reduced.
WHY’S THERE ANY PROBLEM?

Ask the teller for account balance.
If this has fallen to $700,000, reduce annual withdrawal to $35,000 ⇒
Sustainability maintained.

BUT

The teller will advise balance only once a year with ±50% error

Resource abundance known only through annual surveys which have large associated errors
CAN YOU TELL WHETHER $300 000 WAS STOLEN FROM YOUR ACCOUNT?

(Equivalently, whether fish abundance was reduced by 30%?)

In each of the following scenarios shown, the theft occurred in only one of the two cases

Can you tell which one?
IMPRESSIONS

• It wasn’t easy to tell

• It needed usually about 20 years of new data to be certain

• By that time, account was almost exhausted (if theft had occurred)

• By the time the adverse effect of recruitment failure or IUU fishing is detectable, the resource is already heavily depleted
THREE STRATEGIES (MPs)

I: Withdraw $50,000 every year

II: Withdraw 5% of the teller-advised balance each year

III: Withdrawal this year = 80% last year’s withdrawal + 1% teller balance

Strategy must “work” whether or not theft occurred
Annual Withdrawal

No theft

Theft

Withdrawal

Withdrawal

Withdrawal

Withdrawal

Year

Year
Balance in Account

No theft

Theft
Annual Withdrawal

No theft

Theft

Withdrawal

Year

I

II

III

No theft

Theft
Balance in Account

No theft

Theft

I

II

III

Balance in Account
PERFORMANCE

I: Going bankrupt if theft occurred

II: Stabilises balance in account, but annual withdrawals too variable

III: Best of the three – stabilises balance without too much change from year to year

Formula III automatically corrects for effect of recruitment failure/IUU fishing if it occurred.
“Feedback control” (MP basis)
THE MANAGEMENT PROCEDURE APPROACH (MSE)

1) Specify alternative plausible models of resource and fishery (Operating Models – OMs)

2) Condition OMs on data (effectively alternative assessments); pre-specify future data inputs to MP

3) Agree performance measures to quantify the extent to which objectives are attained

4) Select amongst candidate MPs for the one showing the “best” trade-offs in performance measures across objectives and different OMs in simulation testing
WHAT EXACTLY IS AN MP?

- Formula for TAC recommendation
- Pre-specified inputs to formula
But isn’t this the same as the traditional approach?

Almost, but not quite
So what’s the difference?

a) Pre-specifications prevent haggling

b) Simulation checks that formula works even if “best” assessment wrong
How is the MP formula chosen from amongst alternative candidates?

a) Compare simulated catch / risk / catch variability trade-offs for alternatives

b) Check adequate for plausible variations on “best” assessments
SOUTHERN BLUEFIN TUNA EXAMPLE

TRADE OFF

More catch

More recovery

Different HCR options

Year

Catch Biomass
What are the advantages of the MP approach?

a) Less time haggling of little long term benefit

b) Proper evaluation of risk

c) Sound basis to impose limits on TAC variability

d) Consistent with Precautionary Principle

e) Provides framework for interactions with stakeholders, particularly re objectives

f) Use haggling time saved towards more beneficial longer term research
What are the disadvantages of the MP approach?

a) Lengthy evaluation time

b) Overly rigid framework (though 3-5 yearly revision)

BUT

Provides default
When should scientists change the TAC recommendation from a MP?

New information / understanding shows real resource situation is outside range tested

A MP is like an auto-pilot

**BUT**

The real pilot remains to check that nothing unanticipated has occurred (i.e. annual routine assessments continue)
How should managers react to MP-based scientific recommendations?

a) Treat as default (replacing “no change”)

b) Require compelling reasons to change
TRUE BUT UNKNOWN DYNAMICS

OPERATING MODEL

Observed Data

USE DATA TO CALCULATE DESIRED CATCH
- 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
- Small chance of reducing resource to low level
- 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 to changes in the operating model (underlying reality)
How it works

- Operating model
  - provided by alternate assessments

- Management procedure
  - Model-based: simple population model fit and HCR
  - Empirical (e.g. adjust TAC based on trends in abundance indices)
Actually two species:

* M. capensis – shallow-water hake
* M. paradoxus – deep-water hake
Hake Distribution
The 2006 Situation - Past Annual Catches

TAC for 2006: 150’000 tons
Major Uncertainties

- Natural death rate ("Natural mortality")
- Split of catches between two species
- Shape of offspring-parent relationship ("Stock-recruitment curve")
- Recent recruitment levels

Results to be shown reflect 24 possible combinations of these factors
Past Resource Trends

Medians for spawning biomass $B^{sp}$ with full range of values
What is the main problem for the industry?

Both species combined for offshore trawlers

CPUE

1991 1993 1995 1997 1999 2001 2003 2005
What can we do to solve the problem?

MAINTAIN CURRENT TAC

WSSD: RETURN TO MSYL BY 2014 IF POSSIBLE
What can we do to solve the problem?
Trade-Offs

Neither solution is acceptable:

a) the first soon destroys the resource
b) the second leads to severe socio-economic dislocation

A biological/socio-economic trade-off is required

Objectives and their trade-offs must be agreed, and a way found of achieving them in the face of scientific uncertainties that are only partially resolvable
Hake-OMP Data Inputs

CPUE

Survey

M. paradoxus  M. capensis  M. paradoxus  M. capensis

M. paradoxus
West Coast

M. capensis
West coast

M. paradoxus
West coast summer

M. capensis
West coast summer

M. paradoxus
South coast

M. capensis
South coast

M. paradoxus
South coast spring

M. capensis
South coast spring
Objectives agreed for OMP-2006

1. Get catch rates up quickly in the short-medium term

2. Get *M. paradoxus* back to MSYL over 20 years

3. After likely initial cuts to achieve 1), secure greater TAC stability over time.
Two OMP options

OMP details

- TAC changes up or down in response to last 5 years trend \((slope_y)\) in CPUE and surveys
- Minimum rate of increase required for \(M.\ paradoxus\) before TAC might increase

\[
TAC^s_{y+1} = TAC^s_y \left[ 1 + \lambda_y \left( slope_y - slope_{target}(y) \right) \right]
\]

\[
|TAC_{y+1} - TAC_y| \leq \mu TAC_y \quad \mu = \begin{cases} \text{const} \\ \mu(\text{CPUE}_y) \end{cases}
\]
Two OMP options

1) OMP1_20%:
   • Median *paradoxus* recovery to 0.2\(K\), lower 5%ile to 0.12\(K\) after 20 years
   • Max TAC change ±10%

2) OMP2_21%:
   • Median *paradoxus* recovery to 0.21\(K\), lower 5%ile as for 1)
   • 7.5% TAC reductions for 3 years; thereafter max change ±5% but can increase to 15% if CPUE goes low
Two OMP options

Essential trade-off

1) **OMP1_20%**: Higher TAC variability, faster CPUE recovery

2) **OMP2_21%**: Decreased TAC variability, same resource risk as 1), but lower average catch
Projections
OMP1_20%

M. paradoxus

Spawning biomass ('000 t)

TAC (all fisheries)

Catch ('000 t)
Projections
OMP1_20%

M. paradoxus

Spawning biomass ('000 t)

TAC (all fisheries)

Catch ('000 t)
Projections
OMP1_20%

M. paradoxus

Spawning biomass ('000 t)

TAC (all fisheries)

Catch ('000 t)
Projections
OMP1_20%

M. paradoxus

Spawning biomass ('000 t)

TAC (all fisheries)

Catch ('000 t)
OMP1_20%

M. paradoxus

Spawning biomass (000 mt)


Offshore trawl CPUE (both species)

Exploitable biomass (000 mt)


Catch (000 mt)

TAC (all fisheries)


Perc. annual change in TAC


95% ile 75% ile 50% ile
OMP2_21%

Graphs showing biomass and catch trends over time for different categories:
- **M. paradoxus**
- Offshore trawl CPUE (both species)
- TAC (all fisheries)

The graphs display data from 1992 to 2022, with shaded areas indicating variability and a line showing the trend.
HAKE OMP 2010: Final selection

- **OMPf1b**: Average annual TAC 132 000t
  - Max annual incr: 10%; max decr: 5%

- **TAC**

- **BIOMASS**

  - Median
  - 95% PI
  - 75% PI
  - 50% PI
What’s happened Applying OMP-2010

Perc. annual change in TAC

Catch (’000 mt)


Total catch (’000 t)

% annual change in TAC

Hake OMP – 2014 Revision Process

- Update assessments
- Review monitoring data availability
- Revisit objectives and trade-offs
- Modify OMP formulae selection if considered necessary
- Make final selection in September 2014 to apply for the next four years
- Implement OMP-2014 to provide 2015 hake TAC recommendation in October 2014
Updated Assessments

Medians for spawning biomass $B^{sp}$ with full range of values

$M. \ paradoxus$

$M. \ capensis$
Coming Application October 2014

Further updated data

**CPUE**

- **M. paradoxus**
- **M. capensis**

**Survey**

- **M. paradoxus**
  - West Coast
  - West coast summer
  - South coast
  - South coast spring

- **M. capensis**
  - West Coast
  - West coast summer
  - South coast
  - South coast spring
IV. SOME FEATURES OF MPs

- **LIMIT TAC VARIABILITY**

  By construction: \( TAC_{y+1} = \omega TAC_y + (1 - \omega)f(\ldots) \)

  By brute force: \( \left| TAC_{y+1} - TAC_y \right| / TAC_y < x\% \)

- **CONTINUITY**

  Small data changes \( \Rightarrow \) Small TAC changes

  \( \Delta TAC < x \Rightarrow \Delta TAC = 0 \) for some small \( x \)
MPs AND THEIR HCRs:

NEVERTHELESS REMEMBER

What really matters is **NOT** design features of HCRs, but resultant **PERFORMANCE STATISTICS** and their robustness

More complex approaches may introduce noise rather that follow signal
ASSOCIATED NECESSITIES

PRE-AGREED PROTOCOL

• Regular review schedule
  About 5-yearly

• Specifies computation adjustments if data anticipated are not forthcoming

• “Exceptional circumstances” provisions
  When MP output may be overridden and/or review advanced
  Criteria – essentially: situation outside range tested
ASSOCIATED NECESSITIES

DEVELOPMENT SCHEDULE

• Lengthy process compared to assessment (~1 year rather than ~1 week)

• No back-tracking after “milestones” achieved of:
  - Agreeing data and broad range of hypotheses/uncertainties
  - Finalising operating models and fitting them to data

STAKEHOLDER INVOLVEMENT

• Interactions with managers, industry etc. from day one

• Focus on quantifying trade-offs, and associated preferences

• Being part of process → More likely to accept outputs
PROBLEM AREAS

HOW WIDE A RANGE OF UNCERTAINTY TO CONSIDER

• Restrict to range indicated by past data
  The unexpected does occur → Over-frequent recourse to “Exceptional Circumstances”

• Widen range compared to past data indications
  Extent of widening somewhat arbitrary
  TAC outputs are the more conservative as such extents are increased
  Endangers wide acceptability/buy-in
PROBLEM AREAS

DEALING WITH PLAUSIBILITY

• Avoid worst case scenario based management

Plausibility weighting for the different scenarios/trials

• Difficulties of quantification and balance

• A pragmatic approach (IWC): H/M/L ranking
  H – meeting all thresholds
  M – meet lower thresholds
  L - ignore
PROBLEM AREAS

RISK DEFINITION

- Probability of something undesirable happening
- Is a common currency across fisheries possible?
- Common currency can prove problematic even over time in the same fishery
  - e.g. Updates in estimates of the extent of variability in recruitment
- Should be meaningful to non-scientific stakeholders
Thank you for your attention