Preface

This presentation was given at a NZ Seafood Industry Council (SeaFIC) Seminar on 16 November 2010.

The audience was comprised of members of the SeaFIC Policy Council, SeaFIC staff and managers and scientists from the NZ Ministry of Fisheries.

The presentation was an overview of work done in a recent project: it's rationale, approach and some case study applications

This was not intended as a technical presentation. Although there are several technical tables, graphs and diagrams, these were discussed in general terms and mostly used as illustrations only.

Some speaker notes are supplied to clarify what each slide attempts to convey. Where the slide is self-explanatory I have given fewer notes.

Nokome Bentley nbentley@trophia.com 26 November 2010

Developing effective management of low and medium information stocks

or

A framework for enhancing fisheries management decision making

SeaFIC Seminar
16 November 2010
Wellington

Nokome Bentley

I had some difficulty coming up with a title for this presentation. So there are two titles here. The first is the one that David Middleton came up with when announcing this seminar so I thought I better include it. Its OK as a title but it introduces the phrase “low and medium information stocks”. As I hope to show, putting fisheries into boxes like that is not necessarily very useful for effective management. The second title is probably a more accurate description of what I will be discussing today.

I have inserted slides during the presentation a cues to stop for comments or questions - so it would be best if we could wait until then for those.

The project: an overview

- "Management Procedures for New Zealand Fisheries" *a.k.a* "low-info project"
- Funding: 50% Seafood Industry Council ("strategic science" budget), 50% Seafood Innovations
- Small project team: Bentley & Stokes
- Steering group:
  - Ministry of Fisheries: managers, economist, scientists
  - Stakeholders: industry, Maori
  - Science providers: NIWA

Today I will be discussing work that was done as part of a project called "Management Procedures for New Zealand fisheries". The project was funded by SeaFIC and Seafood Innovations Ltd. It had a small team (principally Kevin Stokes and myself) but included a Steering Group with some key people from the NZ fisheries management community.

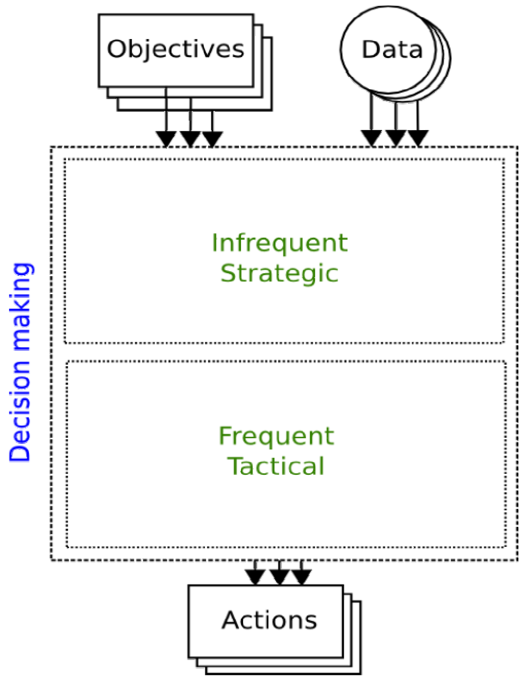
The topic: decision making

- Not about scientific research but rather about **making the most of the available knowledge** to make decisions
- “Fisheries management is like any other form of management: it involves **deciding** what **actions** to take to achieve pre-specified **objectives**.”
- Actions include:
  - **Changing** TAC
  - Doing **monitoring** (routine ongoing data collection)
  - Doing **research** (improving understanding of fisheries)

My background is in science but the focus of today's seminar is not science but rather fisheries management decision making. The work that I describe today does not attempt to progress science (i.e. our knowledge about fish stocks), but rather it attempts to progress how science is used to inform decision making.

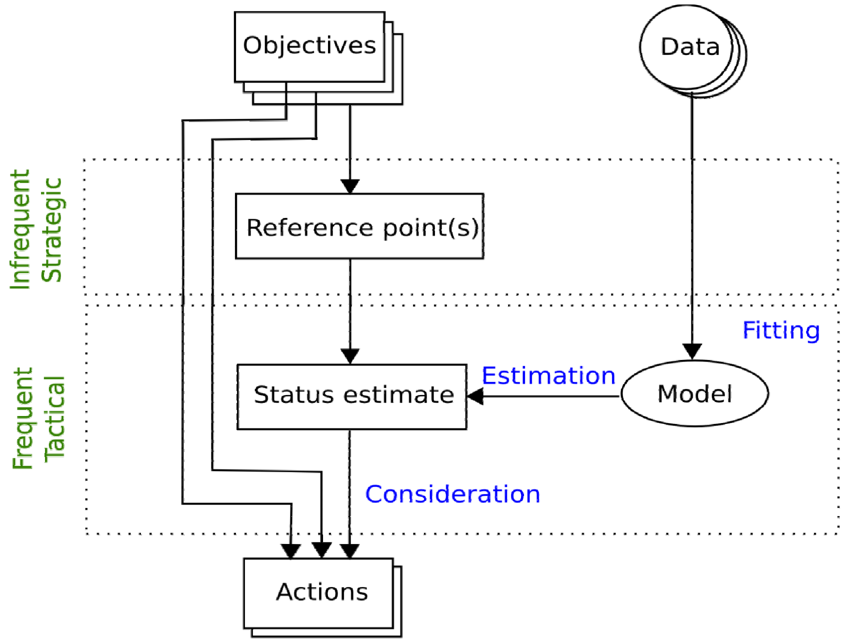
“Fisheries management is like any other form of management: it involves deciding what actions to take to achieve pre-specified objectives.” (I have lifted this quote from one of the papers that was written as part of the project). And in the context of today' talk I will be discussing a framework that is intended to help make decisions around a variety of fisheries management actions: changing TAC, doing monitoring and doing research.

Decision making: objectives + data → actions



In the following slides I am going to be presenting some schematic diagrams representing the decision making process. They follow this basic layout....how do you take management objectives and available data and, through a decision making process, convert them into fisheries management actions. This decision making process can be divided into two phases: infrequent, strategic decision making and more frequent, tactical decision making in support of the strategic decisions.

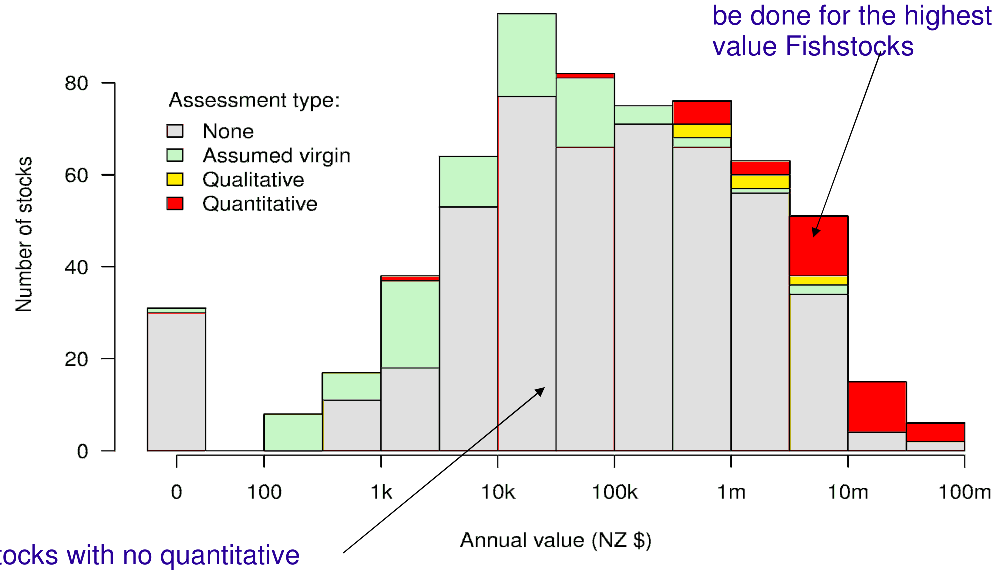
Decision making: the assessment paradigm



The 'assessment paradigm' for fisheries management decision making is to fit a stock assessment model to the available data to produce an estimate of stock status. This estimate is usually compared to a reference point. The status of the stock is considered along with other management objectives, such as profitability and cost efficient management, to decide on some management action. This is clearly a generalised simplification of the 'traditional' stock assessment based approach to fisheries management. But the key thing that I want to point out is that under this approach, most of the decision making is tactical: strategic decision making is largely restricted to the definition of reference points.

The assessment paradigm has failed low value fisheries...

Assessments tend only to be done for the highest value Fishstocks



Fishstocks with no quantitative assessment:
80% by number
65% by TAC
51% by value

The assessment based approach to fisheries management works well for high value fisheries with lots of data. But it has failed to provide responsive decision making for low value fisheries. This is a histogram of the value of all 600+ NZ "Fishstocks" (a quota management area/species combination) according to their value (TACC times port price). Fishstocks which have a quantitative assessment – one that provides an estimate of Bmsy or some other reference point – are shown in red. As you can see, assessments tend to be done for the highest value fisheries. This is of course appropriate given the limited funding and personnel available. Indeed, for many of the low value Fishstocks an assessment would cost more than the value of the annual landings. However, the combined value of these low value fisheries is substantial: in the NZ case around 50% of the total value. In NZ, as in most jurisdictions, without a quantitative stock assessment, management decision making is largely paralysed: some TACC changes are made for stocks without a stock assessment but these changes are usually delayed relative to changes in the stock and are often ad-hoc.

Management procedures: an alternative approach...

- A management procedure (MP) is a **specification of what, and when, management actions** will be taken:
  - “TACC = CPUE x 100
  - “If x<y then change TACC by z% and do a biomass survey”
- Replace more ad-hoc tactical decision making with strict “decision rules”
- Some MPs **can seem simplistic** but they arise from sophisticated development and **evaluation** process
- Emphasis on **evaluation with respect to management objectives** rather than estimation with respect to reference points.

An alternative approach to fisheries management decision making are “management procedures”. MPs are formal specifications of what and when management actions will be taken in response to data from the fishery. They replace more ad-hoc tactical decision making with strict “decision rules”. Although MPs can seem simplistic they arise from sophisticated development and evaluation process. This process has an emphasis on evaluating MPs against management objectives, rather than on estimations with respect to reference points.

CRA8 management procedure

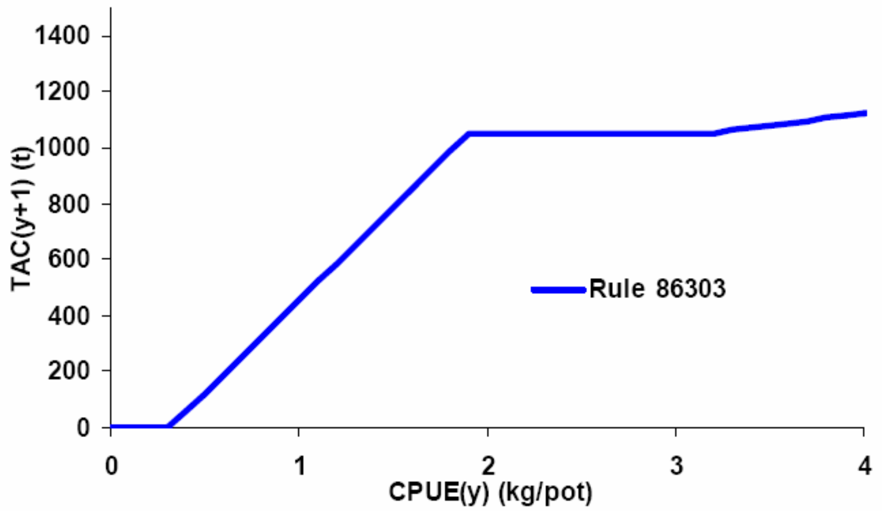
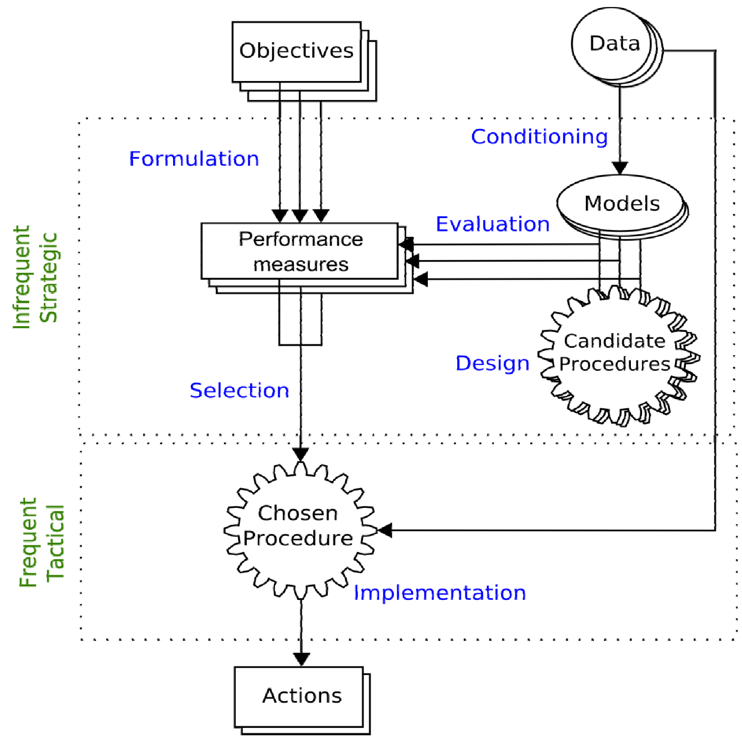


Figure 2: The 2007 CRA 8 management procedure.

From: Breen, P.A.; Haist, V.; Starr, P.J. (2009). New Zealand decision rules and management procedures for rock lobsters (*Jasus edwardsii*).
New Zealand Fisheries Assessment Report 2009/43. 18 p.

Here is an example of a management procedure currently in place in NZ – for rock lobster in Southland. It is a very simple MP that uses the CPUE in a year to set the TAC in the following year. Despite it simplicity this MP has been found, through simulation-based evaluation, to provide good performance with respect to management objectives such as reducing risk of low biomass levels, maximizing yield and reducing variability.

Decision making: the procedural paradigm



The management procedure approach, or "procedural paradigm" to fisheries management decision making is depicted here. I won't go into a lot of detail. The main thing to note is that most of the human decision making occurs during the strategic phase. In this phase, alternative MPs are evaluated using simulation models which are themselves "conditioned" to reflect the data available for the fishery. The evaluation is done with respect to a number of performance measures, representing a number of management objectives and a preferred MP is chosen. The chosen MP represents the chosen management strategy and its annual operation constitutes the tactical decision making for the fishery.

An automotive metaphor for management procedures...

Fisheries management procedure

```
if(biomassTrend<-BiomassThreshold) change = -1;
else if(biomassTrend>BiomassThreshold) change = 1;
else {
    if(sizeTrend<-SizeThreshold) change = -1;
    else if(sizeTrend>SizeThreshold) change = 1;
}
```

=

Car

Fisheries simulation model

Recruitment is modelled using the Beverton-Holt stock re
terms of steepness (η) and with annual recruitment devia

$$R_t = \frac{4\eta R_0 S_t}{S_t(5\eta-1)+S_0(1-\eta)} D_t$$

where S_{t-1} is the spawning biomass in the previous year,

$$S_{t-1} = \sum_{a=0}^{a=A} N_{t-1}^a W^a M^a$$

=

Crash test laboratory

A useful metaphor for management procedures is the automotive industry: if a fisheries management procedure is a car (what you use to “drive” management decision making; groan) then the computer simulation models and the process of management procedure evaluation (a.k.a. management strategy evaluation) is like the crash test laboratory. Just like car designers test alternative designs of car using crash test dummies before releasing them on real people, fisheries scientists test alternative designs of management procedure on simulated fisheries before releasing them on real fisheries. I will extend this metaphor a bit further later.

Comments?
Questions?

The procedural paradigm has failed low value fisheries...

- Focus has also been **high value** fisheries (e.g CRA, SCA, Southern Bluefin Tuna)
- Why? Resource intensive and thus **costly** to develop and evaluate MPs
  - Evaluation has traditionally **followed from a stock assessment**
- Potential ways to reduce costs:
  - Development costs
    - Can we develop **generic ("off-the-shelf") management procedure** that will suit a range of fisheries?
  - Evaluation costs
    - Can we "**pre-evaluate**" generic procedures so we know what **type of fishery** they are best suited for?

Earlier I described how the stock assessment-based approach to fisheries management had largely failed to address low value, data-poor, fisheries. In many ways, the same could be send of the management procedure approach. Thus far, this approach has mostly focussed on high value stocks (for example, in NZ, rock lobster and scallops). This occurs because MPs are costly to develop and evaluate. Part of the reason for this is that evaluation of MPs have usually followed from a stock assessment. This project looked at potential was that the cost of developing and evaluating management procedures could be reduced: through reducing both the development and evaluation costs of MPs.

Expanding the use of management procedures...

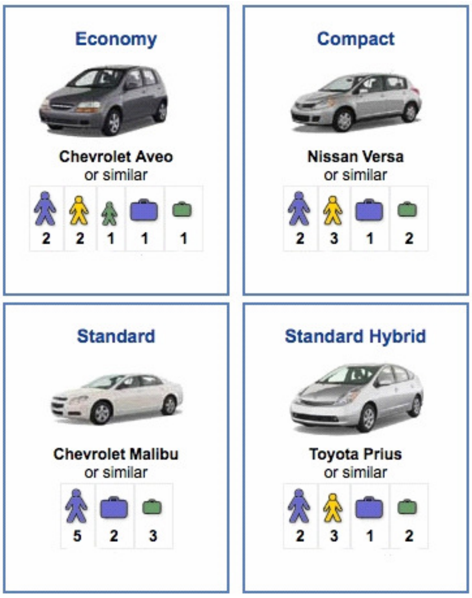
CRA4 CRA5 SCA1 CRA7 CRA8 → STA7 SNA7 BNS1 CRA5 CRA4 SCA1 GUR3 CRA7 CRA8 SKI1 BAR1 SNA2 TRE7 TAR2

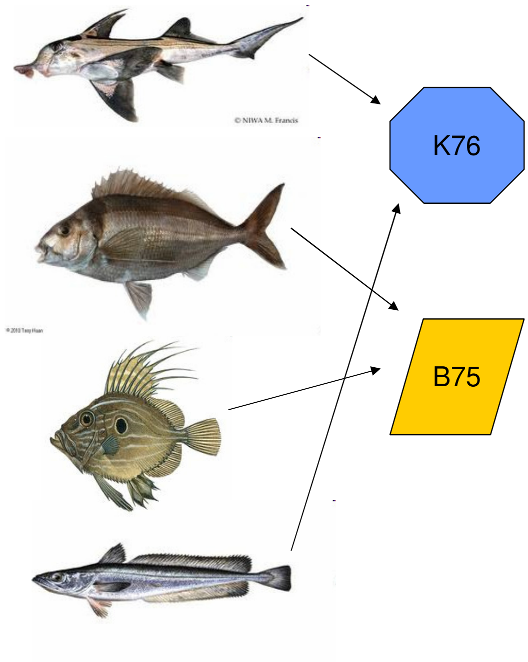
Few, bespoke, high average cost

Many, generic (and bespoke), lower average cost

Going back to the automotive metaphor; in this project, we are attempting to more from the current situation of having a few, bespoke management procedures with a high average cost (like these two high performance Formula 1 cars on a highway in Dubai) to having many, generic MPs (as well as bespoke MPs where we can afford them!) at a lower average cost (like these “standard model” cars on a highway in the US)

Generic does not mean one-size-fits-all





The term "generic" does not mean that we are trying to come up with a one-size-fits-all solution. Just as there are different models of cars designed to suit the different requirements of drivers (for example the number of passengers and amount of luggage they want to carry), so too there might be several 'models' of generic management procedures that are appropriate to different types of fisheries (based on life history and other characteristics).

It has been suggested before…

Improvement of fishery-management advice through simulation testing of harvest algorithms

J. G. Cooke

Closing remark

To date, development and testing of harvest algorithms, and in particular the construction of test scenarios, has required a substantial input of labour by the fishery scientists involved. This has been a limiting factor in the application of the approach to fishery management. However, as experience is gained as to which kinds of harvest algorithms work well, and as a "library" of standard test scenarios accumulates, future implementations of the approach to new fisheries may involve little more than fine-tuning of existing algorithms and test scenarios, so that more general use of the approach becomes practicable.

Schnute *et al*. (2007) identify the need for a global effort within the stock assessment community to develop software to implement general MSE frameworks. However, an equally important need at present is to identify whether there are "universal laws" which pertain to management strategies. Although they remain to be proved, such rules might include "management strategies based on empirical indicators are more likely than model-based management strategies to respond to major shifts in population abundance albeit at the cost of larger inter-annual variation in catches and stock sizes". A global meta-analytic analysis based on MSEs for a variety of regions could be used to "test" such proposed "laws". The availability of sets of such "laws" could be used for regions for which the resources needed to conduct MSEs are lacking.

Refocusing Stock Assessment in Support of Policy Evaluation

André E. Punt

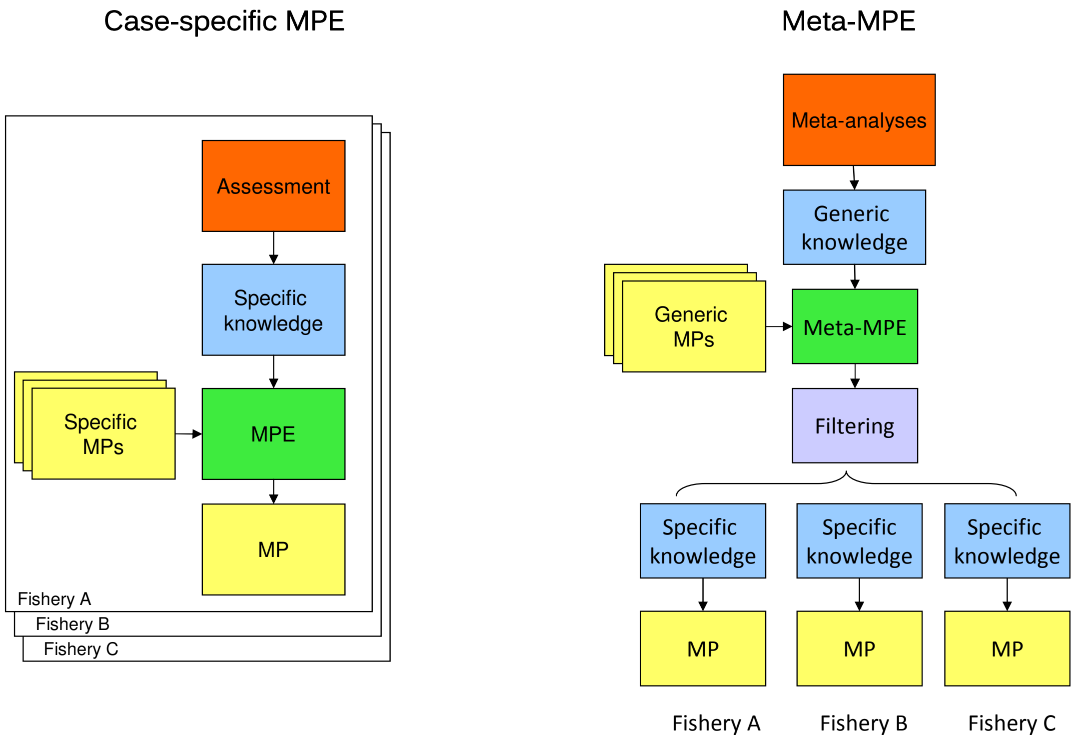
These sorts of ideas are not new: here are some excerpts from some published papers which express similar themes. Cooke (1999) describes how the labour intensiveness of MPE is a limiting factor in its application and how in future, more general application may come from fine-tuning of existing MPs and the simulation models used to test them. Punt (2008) describes the possibility of establishing "laws" about what types of MPs work for different types of fisheries so that they can be applied in cases where MPE is cost prohibitive. The many ways, the aim of this project was to develop a framework for doing the kinds of things that these authors suggest.

Non-aims...

- **Not trying to justify less spending** on monitoring or research – but do provide ways of informing what/how much is appropriate
- **Not trying to justify doing fewer stock assessments**
- **Not suggesting that case-specific work is not needed** – if there are the resources to do it, great
- Not focussed on trying to increase knowledge of fisheries – but rather **making most of what we already know** (however little that is)
- **Not about putting fisheries into boxes**: e.g. low/medium/high information, low/medium/high productivity
- **Not a quick fix** but a **framework for making progress**

Before going into our approach it is also worth pointing out what we were not trying to achieve in this project ("aaims"?). We were not trying to justify less spending on monitoring or research (however we do provide ways of informing what/how much is appropriate). We were not trying to justify doing fewer stock assessments (they can provide an important means of synthesising the available data). We were not suggesting that case-specific MPEs are not needed (if there are the resources to do it, great). We were not focussed on trying to increase knowledge of fisheries, but rather on making the most of what we already know (however little that is). And linked to this, our framework is not about putting fisheries into boxes: e.g. low/medium/high information, low/medium/high productivity. Perhaps most importantly, what we have tried to develop in this project is not a quick fix, but a framework for making progress.

Meta-MPE: lumping then splitting



This slide outlines the basic framework. On the left is how case-specific management procedure evaluation is normally done. A stock assessment is used to generate specific knowledge, in the form of parameter estimates, for a stock. This stock specific knowledge is fed into an operating model (often the same, or very similar to the stock assessment model) and used to evaluate MPs that are specifically designed for that fishery (they may draw on the literature but their implementation in computer code is such that they can't be quickly applied to another fishery). One of the management procedures is chosen based on the evaluations. The process is repeated, usually quite separately, for each fishery.

On the right is the approach that we have used in this project and which we have dubbed "meta-MPE". The approach uses "meta-analyses" to generate what might be called "generic knowledge" on the relative probability of different values of the parameters of fish stock dynamics and on the relationship between those parameters. This generic knowledge is fed into a generalised operating model that is capable of simulating a wide range of fishery scenarios (wide range of population dynamics but also wide range of data collection regimes). Generic MPs that have been programmed in a way that they can be simulated under a similarly wide range of scenarios are then tested using this operating model. The 'meta-MPE' allows for an analysis of questions like "what type of MPs work best when there is a large error in CPUE" or "in which scenarios does this MP produce poor performance" – the types of "laws" of MPs that Punt(2008) alluded to. For individual fisheries, the specific knowledge available, however little that might be, can be used to 'filter out' the results for that particular fishery, so that the most appropriate MP can be selected for that fishery. There is a lot more technical detail to it than that – but that is the basic approach.

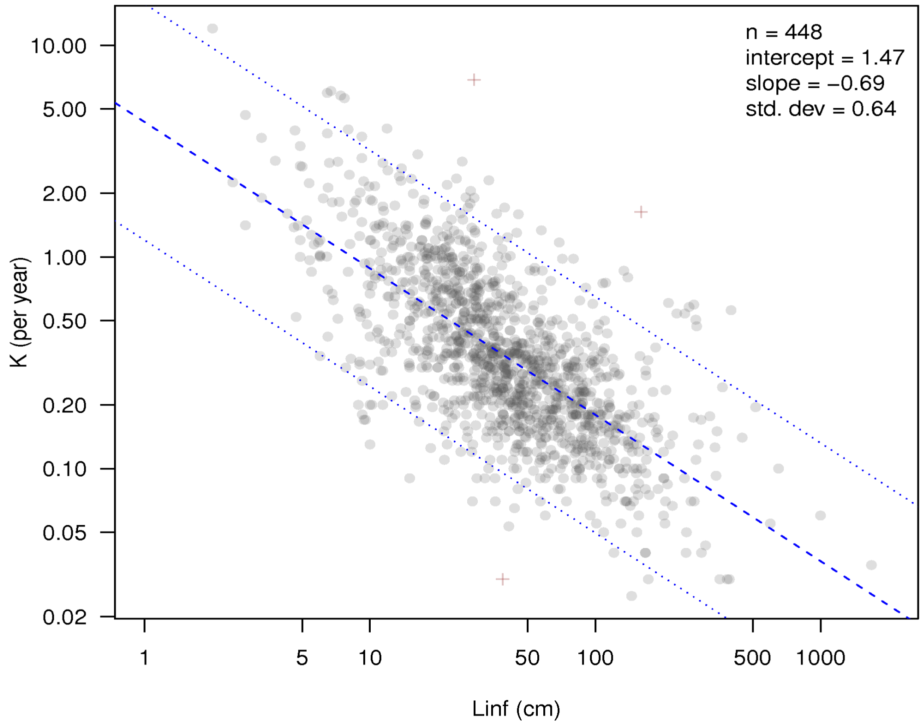
Comments?
Questions?

Meta-MPE: ‘generic’ knowledge

- Generalizations of the knowledge from data-rich stocks are helpful for data-poor stocks: “robin-hood” effect
- Examples of **meta-analysis**, **life history theory** for fish: e.g.
  - Pauly (1980) M-growth-temperature relation
  - Charnov (1993) “life history invariants”
  - Myers et al (1999) stock-recruitment database
  - Harley et al (2001) hyper-stability/depletion of CPUE
- FishBase – database of life history characteristics of many fish species

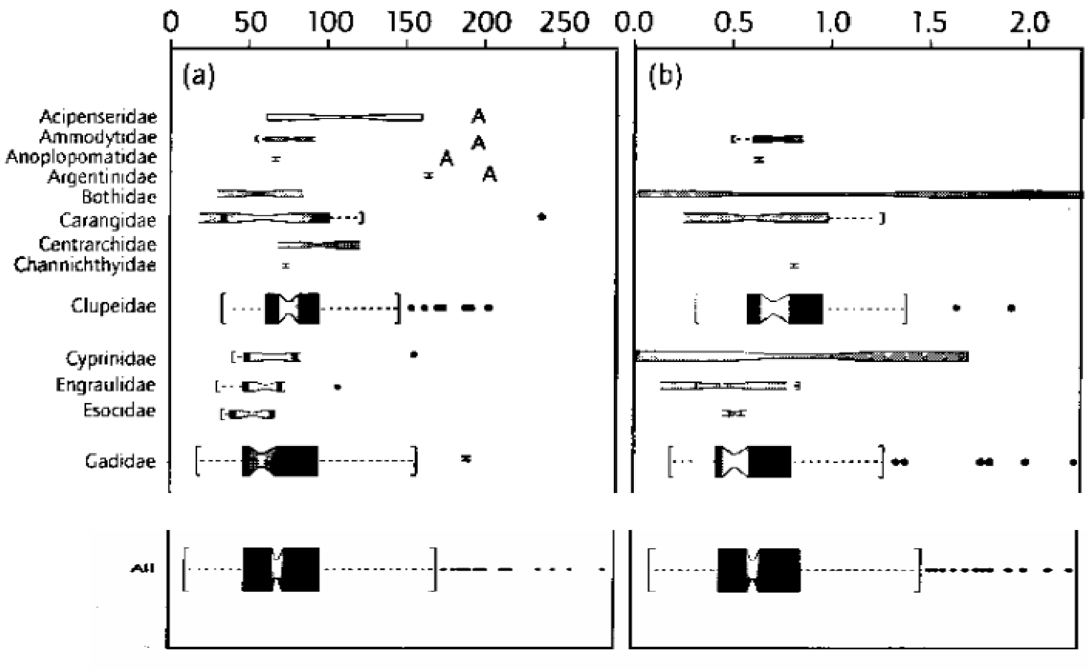
As I described, the “meta-MPE” approach tries to make the most of “generic knowledge” about fish stocks and fisheries. There are several example of studies that have used statistical meta-analyses or life history theory to develop such generalisations. There is also the FishBase database which contains estimates of life history parameters from many fish species.

Generic knowledge: e.g. relationships between growth parameters



Here is an example of some data from FishBase – the relationship between asymptotic length and growth coefficient used in this project.

Generic knowledge: e.g. variability in recruitment



Another example of generic knowledge – estimates of the variability in recruitment from Myers (2002)

Generic knowledge: e.g. relationships between parameters expected by theory

Abstract—Priors are existing information or beliefs that are needed in Bayesian analysis. Informative priors are important in obtaining the Bayesian posterior distributions for estimated parameters in stock assessment. In the case of the steepness parameter (h), the need for an informative prior is particularly important because it determines the stock-recruitment relationships in the model. However, specifications of the priors for the h parameter are often subjective. We used a simple population model to derive h priors based on life history considerations. The model was based on the evolutionary principle that persistence of any species, given its life history (i.e., natural mortality rate) and its exposure to recruitment variability, requires a minimum recruitment compensation that enables the species to rebound consistently from low critical abundances (N_c). Using the model, we

A prior for steepness in stock-recruitment relationships, based on an evolutionary persistence principle

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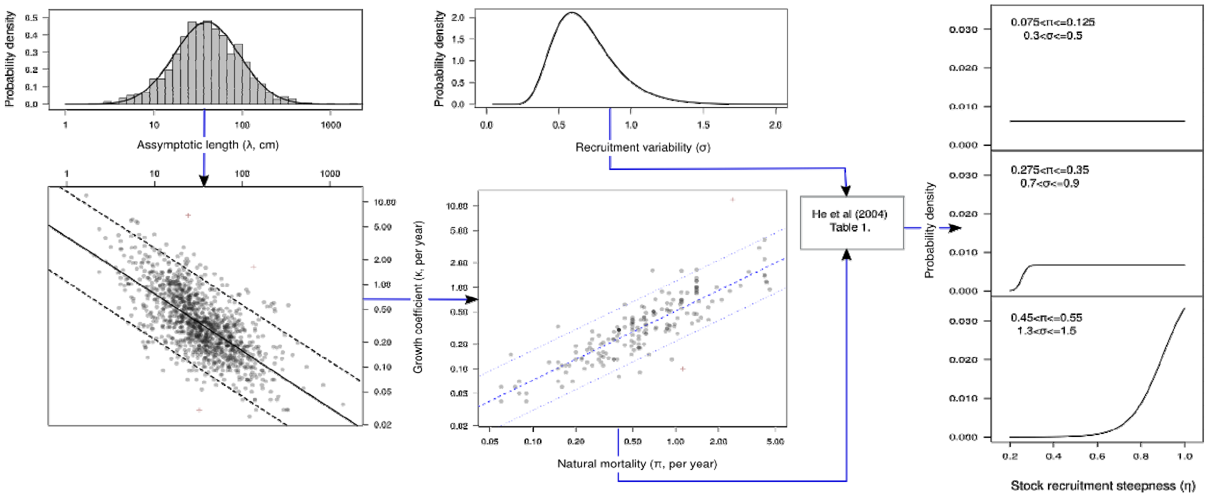
A final example of generic knowledge, this one from life history theory. He et al (2006) used evolutionary theory to develop expected probability distributions for the steepness of the stock recruitment relationship based on the natural mortality and recruitment variability that the stock was exposed to. I include this example, to emphasise that we are not necessary limited to meta-analyses of data in order to derive generic knowledge – basic life history theory is also useful in restricting the combination of parameter combinations to a feasible space.

Generic knowledge: allows for "imputation"



One of the reason that this generic knowledge is useful is that it allows for inference of population parameters based on what knowledge that we do have. In statistics, this "filling in the gaps" is known as imputation. This diagram shows the Bayesian network that we used in our meta-MPE – it shows the assumed relationships between asymptotic length, growth coefficient, natural mortality, recruitment variability and stock recruitment steepness. Using this sort of network, it is possible to infer something about the likely range of one parameter given another. For example, if an estimate of asymptotic length is available (for example, based on the maximum observed length) then it is possible to infer probability distributions for the other parameters.

Comments?
Questions?

Management procedures: creating a (small) library

- Already several **classes** of management procedure developed for fisheries around the world
- Most MP classes are **already fairly generic** – have **parameters that can be tuned** to suit different fisheries
- To be used in meta-MPE framework need to be implemented (in computer programming code) so that they
  - work under a wide range of possible scenarios
  - work with a variety of data sources
- For this project implemented a limited number of MP classes: three that illustrate a range of data requirements:
  - TPMA (Target proportion of maximum abundance): CPUE or survey only
  - TRZK (Target range for Z/K): mean weight, mean length or age frequency only
  - MAST (Matrix of abundance and size trends): CPUE or survey and mean length data

In our meta-MPE we only used a small library of generic management procedures. We chose these to be illustrative of the range of data requirements of MPs. These management procedures are not linked to any one source of data. For example, TRZK estimates the ratio between total mortality and the growth coefficient using regularly collected estimates of mean weight, mean length or age.

Management procedures classes: e.g. MAST

- Each class has **control parameters** that can be adjusted
- Operated every *f* years
- Changes TACC up or down by **a fixed proportion (*c*)**
- Based on **trends in size and abundance** over **fixed time horizon** (*h* years)
- Separate thresholds for what is considered a significant up or down trend in abundance or size
- Can use alternative sources of data for abundance – survey or CPUE

		Abundance trend		
		+	0	-
Size trend	+	+	+	-
	0	+	0	-
	-	+	-	-

I will describe one of these MPs, "MAST", in slightly more detail….

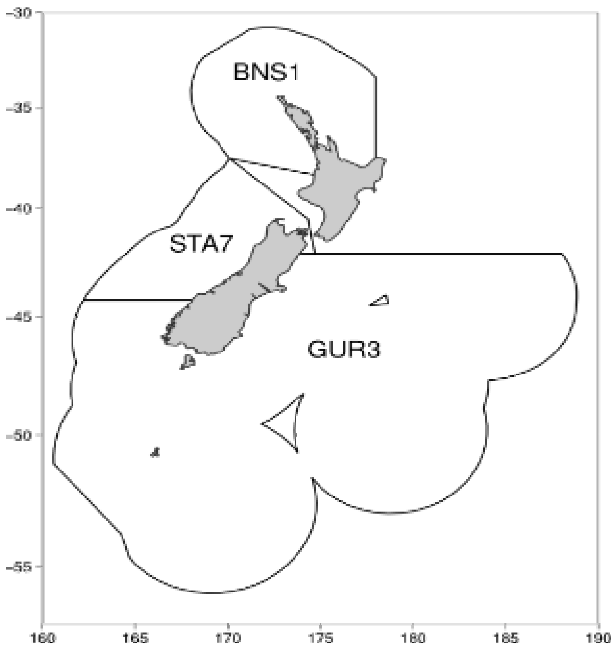
Management procedure instances

- A specific MP class with a certain set of control parameters is an instance
- MAST(2,5,3,0.05,50,0.2,0.1) =
  - operated every 2 years
  - trends calculated over previous 5 years
  - abundance index from survey (3)
  - abundance trend significant if greater than +/- 5%
  - mean length based on effective sample size of 50 fish
  - mean length trend significant if greater than +/- 20%
  - change in TACC of +/-10%
- For each MP class tested about 1700 instances (combinations of parameters)

When evaluating classes of MPs over a wide range of different scenarios it is necessary to evaluate many instances. Each instance represents a particular combinations of the classes' parameters. A large number of parameter combinations (instances) needs to be evaluated because for a particular scenario, only a particular combination may be appropriate.

Case studies

- Chosen to span a range of
  - population dynamics
  - extents of data and knowledge
- A test of ability to rapidly apply framework to actual fisheries
- Still being completed



For this project we did three illustrative case studies…

Specific knowledge: quick stock-take from reports

MFish Plenary report

Fisheries Assessment Reports (FARs)

SeaFIC Adaptive Management Programme (AMP) Reports

Estimated parameters

Type	Parameter	Symbol	GUR3	STA7	BNS1
Biological					
Mortality	Instantaneous rate of natural mortality	π	U(0.2,0.4)[1]	U(0.1,0.3)[2]	A: U(0.04,0.08)[3] B: U(0.2,0.4)[4] C: ~ κ *
Growth	Asymptotic length	λ	U(41.2,50.1)[5]	U(78.8,84.0)[6]	A: U(72,93)[7] B: U(80,90)[8] C: U(70,100)[9]
	Growth coefficient	κ	U(0.390,0.530)[10]	U(0.116,0.133)[11]	A: U(0.07,0.13)[12] B: U(0.24,0.36)[13] C: ~ λ *

Observed variables

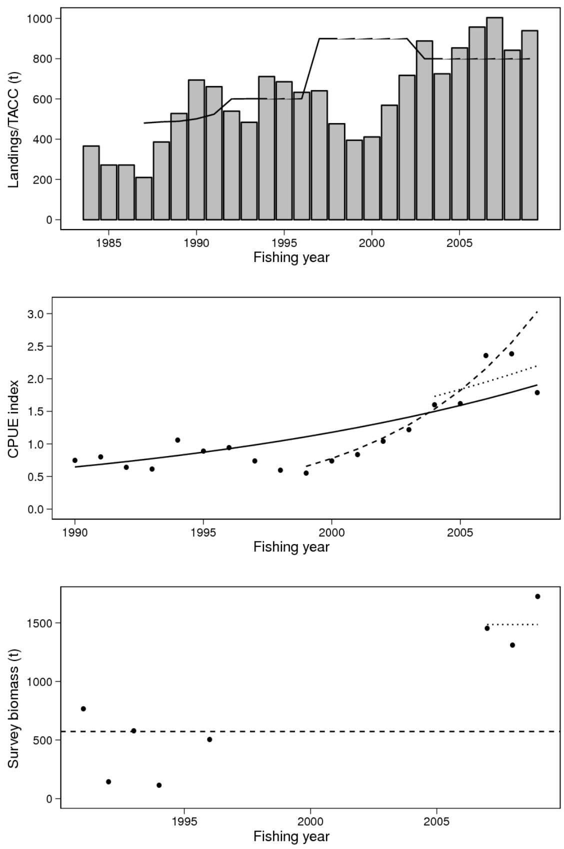
Group	Description	GUR3	STA7	BNS1
Catch	Current catch relative to mean catch	U(123%,185%)	U(101%,152%)	U(76%,114%)
	Current catch relative to maximum catch	U(75%,112%)	U(56%,83%)	U(48%,72%)
CPUE	Slope of over entire series	U(4%,8%)	U(-1%,3%)	U(-8%,-4%)
	Slope of over last 10 years	U(12%,20%)	U(-4%,0%)	U(-12%,-6%)
	Slope of over last 5 years	U(4%,8%)	U(-2%,2%)	U(-20%,-10%)
	Coefficient of variation	U(0.41,0.61)	U(0.14,0.21)	U(0.31,0.46)
	Average annual variation (%)	U(0.17,0.25)	U(0.12,0.18)	U(0.12,0.18)
	Inter-annual volatility (s.d. of log changes)	U(0.19,0.28)	U(0.16,0.24)	U(0.15,0.23)
Survey	3 year multiplier	U(1.5,3.5)	U(0.9,1.4)	

Consistent with the aims of the project, each case study had to be able to be done in a relatively short amount of time but use the most of whatever information was available for each fishery. I used the MFish plenary document, FARs and SeaFIC reports to derive prior distributions for both model parameters and observed variable. The priors for the observed variables are used to 'condition' the simulation model – to restrict it to the parameter space that is consistent with the observed data. It took less than a day to develop these priors for each stock. During the 'real' application of the approach, the establishment of these priors would involve discussion with the relevant Working Group and thus take longer.

Specific knowledge: e.g. GUR3

- Trends in catch, CPUE and survey data are summarised to a few variables

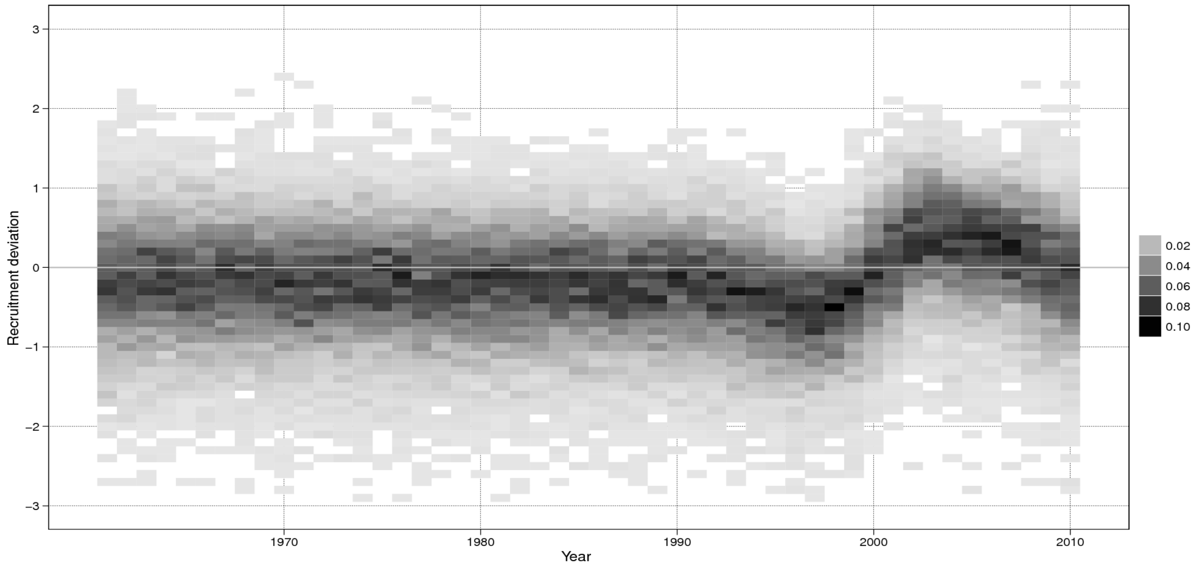
Description	GUR3
Current catch relative to mean catch	U(123%,185%)
Current catch relative to maximum catch	U(75%,112%)
Slope of over entire series	U(4%,8%)
Slope of over last 10 years	U(12%,20%)
Slope of over last 5 years	U(4%,8%)
Coefficient of variation	U(0.41,0.61)
Average annual variation (%)	U(0.17,0.25)
Inter-annual volatility (s.d. of log changes)	U(0.19,0.28)



Here are examples of the priors placed on variables reflecting catch and CPUE. In a usual stock assessment, such data is used to 'drive' the model (in the case of catch), or is fitted to (in the case of CPUE). In contrast, in the meta-MPE approach, a wide range of simulations are done but only those which are consistent with the observed variables are used for the MP evaluations for the particular Fishstock.

Filtering: e.g. GUR3 recruitment variation

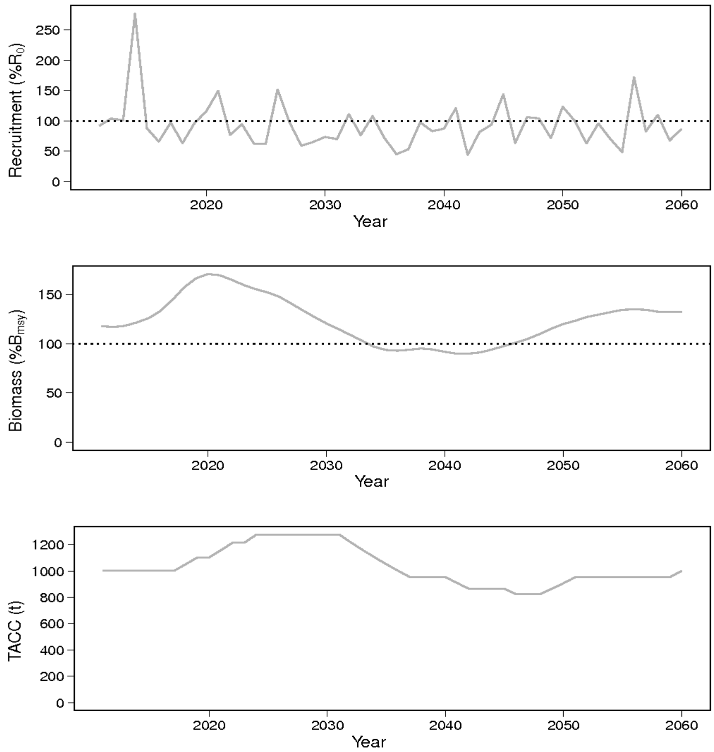
- Filter meta-MPE realizations so that only simulation scenarios that are consistent with observed variables are used
- Surprising amount of information in broad variables used



Whilst (a) many of these case-studies are probably considered data-poor and (b) the approach used to apply the observed data is crude, there is a surprising amount of information available simply by synthesising what is in published reports. This example shows the recruitment deviates for the simulations that were 'filtered out' for GUR3 – the high recruitment in the early 200s being consistent with the observed increase in CPUE and survey indices. In many ways, the 'filtering' or 'conditioning' step becomes close to a rapid mini stock assessment.

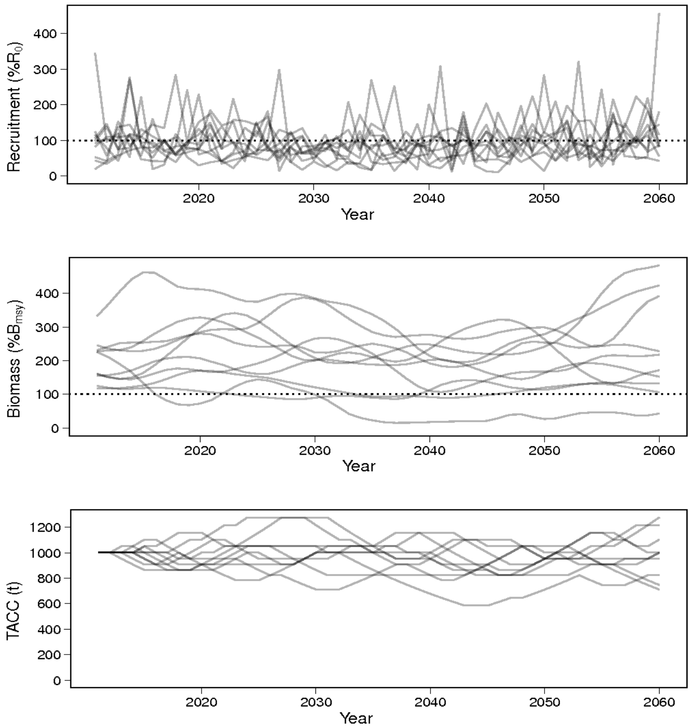
Comments?
Questions?

STA7: 1 MP, 1 realizations



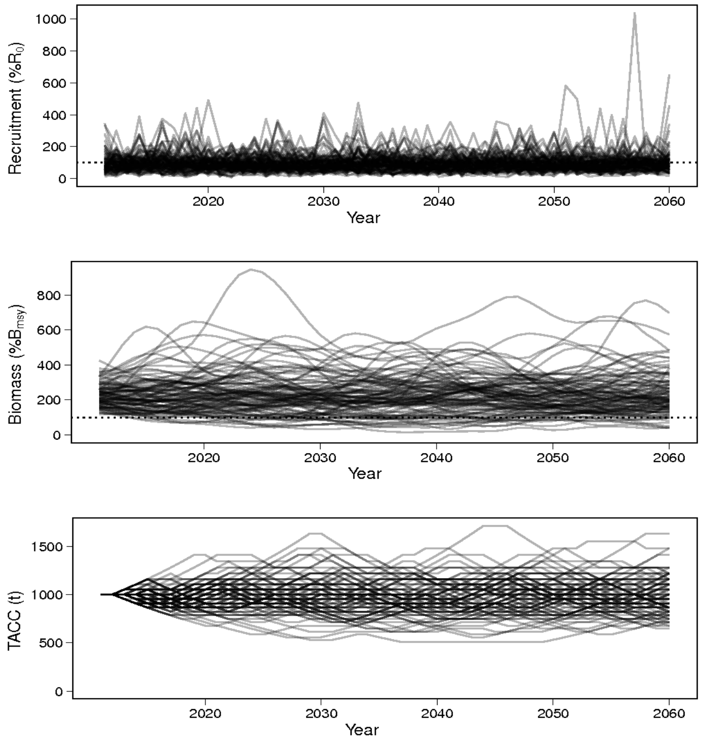
The following examples illustrate how the management procedure evaluations are done by projecting forward with different realizations…

STA7: 1 MP, 10 realizations



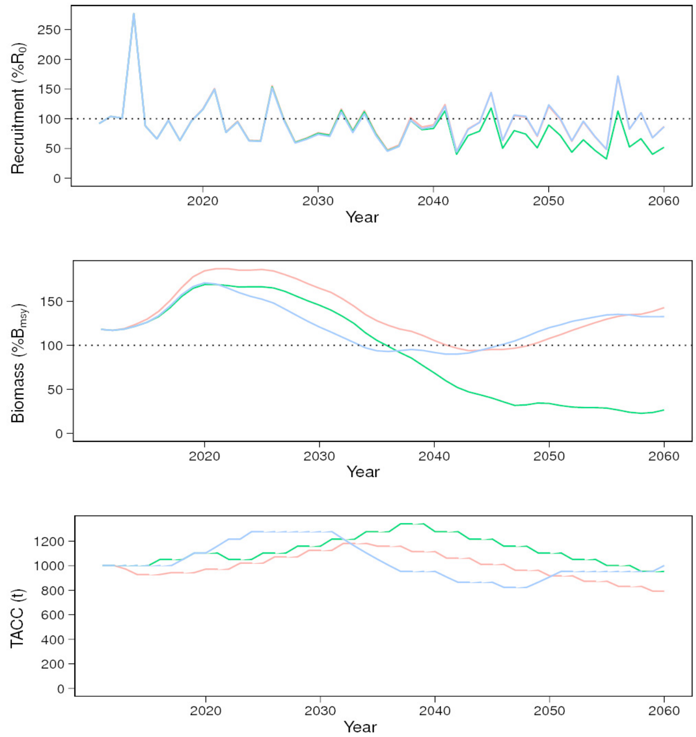
…10 realizations…

STA7: 1 MP, 100 realizations



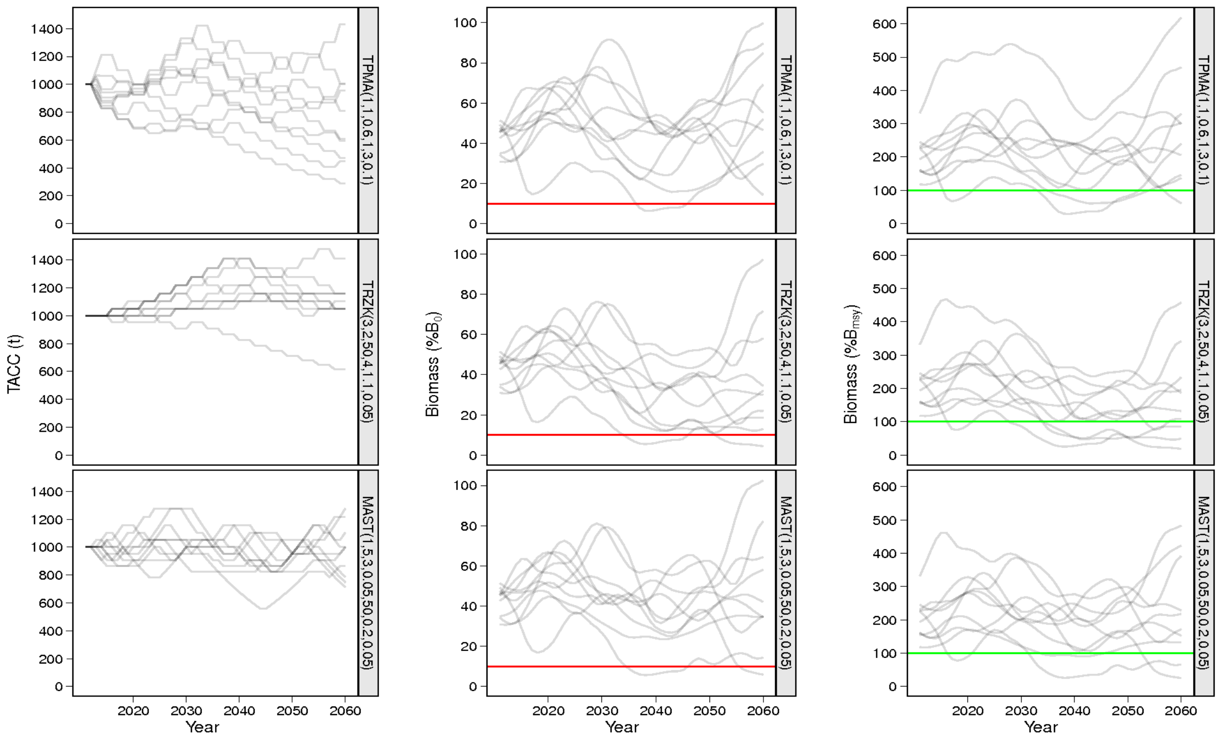
…100,…

STA7: 3 MPs, 1 realization



In fact, for each realization, we test all the management procedures. Note for this particular realization that the MP shown in green performs poorly – it has too much delay - it increases TACC too slowly after biomass increases - and thus drives the biomass to low levels.

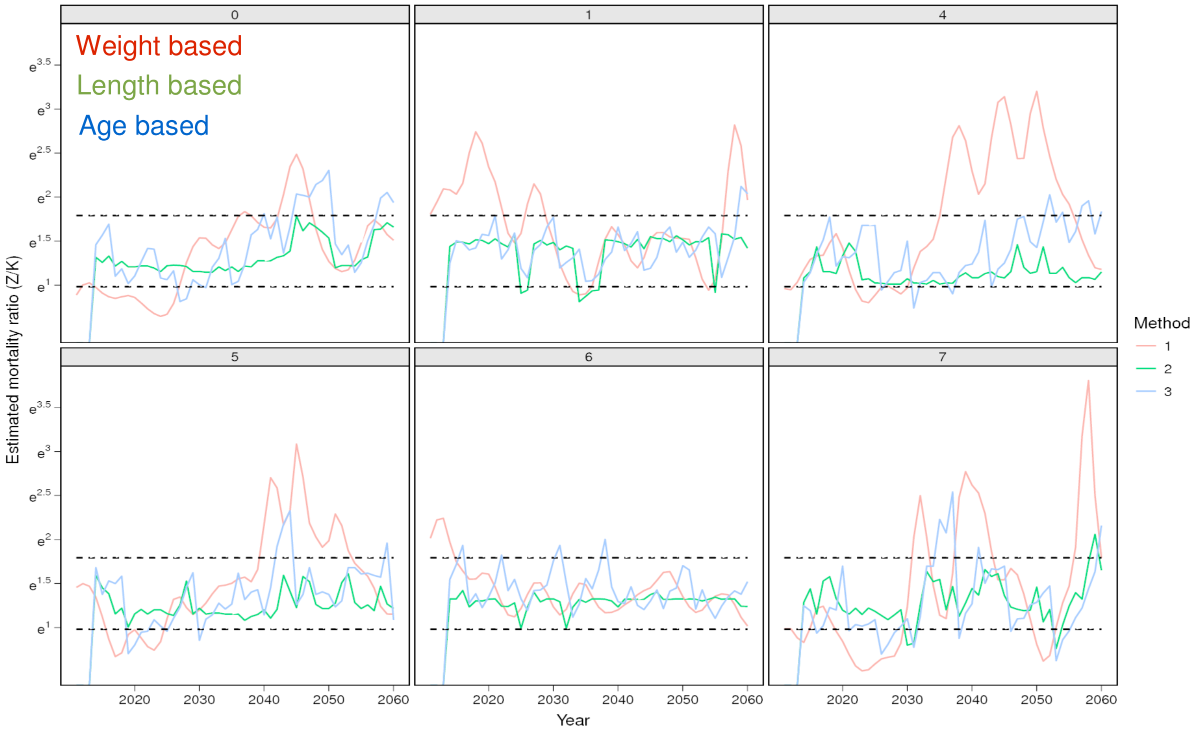
STA7: 3 MPs, 10 realization



Here is another way of comparing 3 MPs. In this figure I also illustrate how the MPs perform relative to performance measures such as the probability of falling below 10% B0 (red line) and staying close to or above Bmsy (green line).

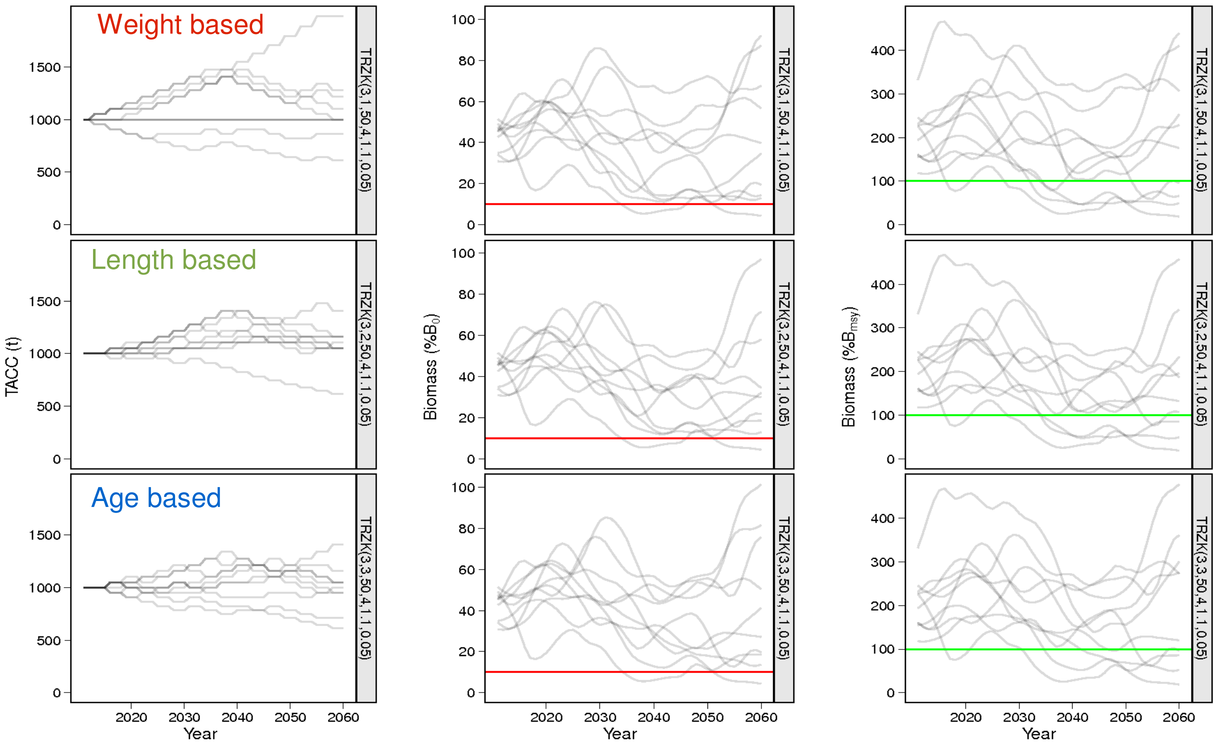
Comments?
Questions?

Prioritizing monitoring: TRZK with different data



Because the generic management procedure are formulated so that they can use different forms of data we can evaluate alternative forms of monitoring. This figure shows six realizations in which the Z/K ratio is calculated from different sources of data. The dotted lines show the target range for this ratio as specified by a particular instance of the management procedure class TRZK (Target Range for Z/K). Note that although the different methods give different estimates, they are broadly consistent, and the cheaper weight and length based methods may still provide sufficient management performance.

Prioritizing monitoring: different data, different outcomes



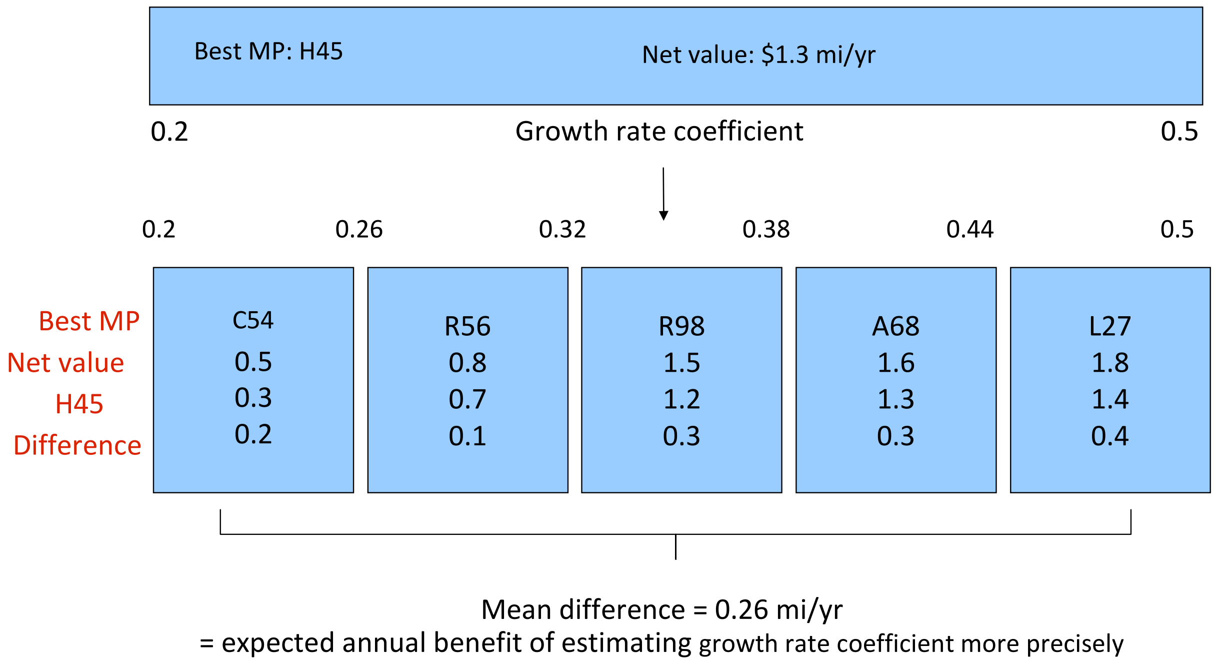
Here are the outcomes of "driving" that TRZK MP using the different data sources.

Prioritizing monitoring: weighing costs versus benefits

Management procedure	Monitoring	Safety	Yield (t)	Annual ACE value ('000 $)	Annual monitoring cost ('000 $)	Net ('000 $)
CONS	?	0.957	1016.7	508.4	?	?
TRZK(1,3,50,4,1.1,0.1)	Age 50 fish every year	0.981	1094.7	547.4	30	517.4
TRZK(2,2,50,3,1.5,0.4)	Measure 50 fish every 2 years	0.981	958.2	479.1	10	469.1
TRZK(2,1,20,2,1.5,0.1)	Estimate average weight every 2 years	0.981	736.7	368.4	3	365.4

We can use those results to then inform decision making about the cost effectiveness of different monitoring. This table shows some simple calculations that converts the predicted annual yield into an annual value and weighs these against the costs of the alternative monitoring options. "CONS" is the constant catch "MP" – note that it has a lower safety i.e. higher risk than the other MPs. In this hypothetical example, the extra yield from using age data outweighs the extra cost.

Prioritizing research: MPE subset analysis



In addition to prioritizing monitoring (regular data collection to feed into MP), we can also prioritize research (irregular investigations to refine knowledge). More precise knowledge allows the selection of MPs that are more finely tuned to the underlying dynamics of a stock and thus provide better management performance. By subsetting the results of an MPE we can look at the sensitivity of the choice of "best" MP to refinement of parameter values. This allows for some guidance on the best "bang-for-buck" for research.

BNS1 example : research priorities

Gains in annual long term yield

```
Current:730
Utility:983.902

P Selectivity50 72.1201
       0.0105529-0.253359       547.725      652.085      104.36       6135
       0.253359-0.485681        577.599      704.258      126.659      4584
       0.485681-0.717909        836.333      880.789      44.4558      6079
       0.717909-0.98944         1973.95      1986.96      13.0057      726

F AgesQ10 48.3874
       0.5-1.5                  531.934      633.725      101.791      6139
       1.5-2.5                  844.07       921.338      77.2682      6083
       2.5-3.5                  949.54       953.333      3.79315      732
       3.5-11.5                 2016.69      2027.39      10.697       726

F LengthsMean 47.5722
       26.3727-53.8507          446.757      504.431      57.6743      6079
       53.8507-62.2862          695.441      789.261      93.8194      6147
       62.2862-71.0889          905.043      929.569      24.5267      4605
       71.0889-86.8765          1888.37      1902.64      14.2684      726
```

Yield under current MP | Yield under best MP | Gain in yield | Best MP

As part of this project, we developed software for doing this sort of analysis based on the results from MPE (any MPE, not just meta-MPE). Here are results for the BNS1 case study. These results suggest, that for BNS1 where the selectivity ogive is unknown, that the biggest gains in performance (here simply defined on the basis on long term yield) would come from refining the prior for the parameter “Selectivity50” (the length at 50% selectivity). Note also though that the analysis ranks highly the gains to be add from obtaining data on variables such as “Ages10” (10th percentile of catch age distribution) and “LengthMean” (mean length of catch), presumably because they are a function of selectivity and thus confer information about “Selectivity50”

Prioritizing research: MPE subset analysis

- Not an attempt to provide accurate cost-benefit analysis. Provides:
  - Guidance on how to move forward with research
  - Illustration of the payoffs from investing in science
- Some science projects will simultaneously reduce uncertainty in several parameters (e.g stock assessment) – more difficult, but possible, to evaluate.

Such an analysis is not an attempt to provide accurate cost-benefit analysis for research but it does guidance on how to move forward with research…

Prioritizing MP development

- Can't "research our way out of everything" e.g stock recruitment steepness, regime shifts
- Uncertainty can also be tackled by inventing MPs that are robust to uncertainty
- Analyse MPE results to identify which parameters the existing library of MPs is most sensitive to and attempt to "engineer around" these with alternative types of MPs

In addition to helping prioritizing research, such an analysis also helps to prioritize MP development i.e. the invention of new MPs to add to "the library"…

Next steps

- Expand library of MPs. **Develop more intelligent MPs** e.g. Feasible Stock Trajectories (FST)
- Create the operational infrastructure to:
  - **deploy MPs** - a revised and expanded version of the software used for this project
  - **operate MPs** - code to interface with MFish and other databases so that annual operation of MPs is efficient
- Modelling of fleet dynamics:
  - Assuming that TACC is always taken overestimates risk
- Tackle multi-species issues

There is still plenty to be done. What was developed under the current project was largely illustrative and if there is to be widespread deployment of MPs in NZ as outlined here, then we will need to move into "production" mode. This would involve a revision of almost all of what was done in this project including meta-analyses, the generic operating model and software for analysis of results. In addition, if there are going to be numerous MPs being operated then there needs to be an infrastructure for efficiently operating them each year. There is also a need to examine modelling fleet dynamics and multi-species issues – both are important in the NZ context. There is much potential for collaboration, both within NZ and overseas. We are already discussing the potential to collaborate on such work with colleagues in Australia and South Africa. For example, meta-analyses done in South Africa could be used to add to the generic knowledge for a meta-MPE applied to a NZ fishery. Or, a MP developed in Australia and added to a library of generic MPs, could become immediately available for evaluation for a NZ fishery.