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Expert Review Panel Report
Review of the New Zealand South Island trawl surveys
26 October 2012

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Preface

The Ministry for Primary Industries and its predecessor, the Ministry of Fisheries, have conducted fully-independent expert reviews of stock assessments, research methodologies and research programmes since 1998. We also run specialist technical review workshops to further advance fisheries and other marine science methodologies and techniques. These fully-independent reviews and technical workshops are separate from, but complementary to, the annual Science Working Group processes that are used to ensure the objectivity and reliability of most of our scientific research and analyses.

A new publication series, Fisheries Science Reviews, has been initiated in 2015 to ensure that reports from these reviews are readily accessible. The series will include all recent and new fully-independent reviews and technical workshop reports, and will also incorporate as many historical reports as possible, as time allows. In order to avoid confusion about when the reviews were actually conducted, all titles will include the year of the review. They may also include appendices containing the Terms of Reference, a list of participants, and a bibliography of supporting documents, where these have not previously been incorporated. Other than this, there will be no changes made to the original reports composed by the independent experts or workshop participants.

Fisheries Science Reviews (FSRs) contain a wealth of information that demonstrates the utility of the processes the Ministry uses to continually improve the scientific basis for managing New Zealand's fisheries.

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Expert Review Panel Report
Review of the New Zealand South Island trawl surveys
26 October 2012

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Review process

The New Zealand Ministry for Primary Industries (MPI) convened a review of the New Zealand South Island trawl surveys on 15-18 October 2012 in Wellington, New Zealand. The review included: presentations by Expert Panel members about trawl surveys in their own countries, presentations by the scientists working on the NZ South Island trawl surveys and associated analysis and modelling, questions and discussion about the trawl surveys, and conclusions from the Expert Panel. The Review Panel was provided with reference material located on a dedicated web page.[1]

This report summarizes the conclusions of the Expert Panel, for each Term of Reference (ToRs are denoted by italics).

Background

The New Zealand Fisheries Act (1996) was amended in 2008 to allow the possibility of setting a total allowable catch that is "not inconsistent with the objective of maintaining the stock at or above, or moving the stock towards or above, a level that can produce the maximum sustainable yield", even if the current level of the stock or the level of stock that can produce MSY is not able to be estimated reliably using the best available information. This implies the use of proxies for MSY reference points where they cannot be estimated directly. The October 2008 Harvest Strategy Standard for New Zealand Fisheries (the HSS) incorporates this approach, which is further operationalised in the 2011 draft National Fisheries Plan for Inshore Fin Fish (the Inshore Fisheries Plan) which classifies stocks into seven 'groups' to facilitate multi-stock objective-setting to translate the *Fisheries 2030* goal and outcomes. These groupings relate to commercial and recreational importance, vulnerability and other characteristics that determine priorities for data collection and management expenditure. Trawl surveys provide an opportunity to provide information on stock trends and population structure for a wide variety of species spanning several of the Inshore Fisheries Plan species groupings, and development of proxies for MSY reference points. In the following review, the Review Panel has considered the types of information that could be collected and if the surveys are fit for this purpose.

1. *Management Objective*

   i. *Assess whether the survey is fit for the purpose of addressing the management objectives (see below). In other words are the surveys providing a reliable index of abundance as well as indices of biological trends (age, length) for these stocks?*

[1] http://cs.fish.govt.nz/forums/1183/ShowForum.aspx

Overall, we found that the east and west coast South Island surveys have been designed and conducted according the best standards practised elsewhere. The surveys are in principle highly suitable for monitoring the inshore demersal stocks and the performance is likely to be limited more by uncontrollable factors such as variability in fish behaviour than by deficiencies in survey design.

The utility of the surveys for addressing management objectives will have to be determined by their performance in operation. Given that analytical stock assessments are not currently planned for the species covered by the surveys, it is assumed that the survey estimates of biomass will be used directly to determine stock status. Further, targets and limits have not been explicitly defined for many stocks and it may be possible to derive proxies for these limits from these same survey time series. Finally, basic methods such as estimating relative fishing mortalities (catch/survey biomass index) may provide a useful proxy for estimates of fishing intensity over years.

The Review Panel had insufficient information to determine for which species the survey will provide an adequate proxy for stock status or an MSY-compatible reference point. The Panel recommends analysis to determine if observed trends in biomass and length/age structure represent coherent population dynamics signals; for example, if stock biomass is responding predictably to changes in recruitment and/or fishing pressure.

If the survey data cannot provide adequate proxies for biomass-based reference points and stock status, then other approaches such as those based on commercial fishery data could be used. There are many arguments why commercial fishery-based alternatives would or do not track stock biomass, but they could be used as proxies for targets and stock status if accurate formulations were identified.

ii. *What other survey data could be used to inform other management objectives?*

Other management objectives such as maintaining biodiversity; protecting endangered, threatened or protected species such as those covered by the National Plan of Action for Sharks (2008); and other aspects of ecosystem-based management plans are supported through survey data in many other countries. In addition, surveys often provide information needed to support Principle 2 (ecosystem impacts) requirements for Marine Stewardship Council certification.

Surveys also provide early indications of year-class strength, changes in maturity-at-age, growth and mortality that can be difficult to determine from commercial fishery data due to the effects of gear selectivity and the distribution of fishing activity. While these indicators may not feed directly into the stock status for management objectives they do indicate potential changes to productivity that should be taken into account

2. Survey design

i. *What is the appropriate survey frequency?*

Survey frequency will depend upon life history (short or long lived), recruitment variability and requirements for provision of stock status advice. If the survey estimates are not used to determine stock status in terms of fishable biomass, but are used instead to detect recruitment trends, then more frequent surveys may be required. Whichever purpose the survey estimates are used for, survey frequency is probably best evaluated in a Management Performance Evaluation framework. Advice on determining frequency of assessments given in ICES (2012)[2] may provide guidance on the frequency of surveys if biomass estimates are being used to evaluate stock status.

ii. Is the stratification used in the surveys appropriate to assess heterogeneous areas of habitat?

2 http://www.ices.dk/reports/ACOM/2012/WKFREQ/WKFREQ_Executive_summary.pdf

It is common practice to use stratified random survey designs to partition larger heterogeneous areas into smaller more homogenous areas with respect to variability in the quantities being measured. In trawl surveys, the heterogeneity is assumed to correspond to different habitats that determine differences in fish distributions and abundance. The current designs for the east and west coast South Island surveys use depth and basic geographical boundaries to define stratum boundaries as proxies for "habitat". The Panel did not have any further information on the persistence of spatial distributions of fish in the survey (or from fishery data), or on elements that may define habitat such as bottom type, community structure, currents or water column characteristics, and could not determine if actual quantifiable habitat differences have been captured by the boundaries. However, the strata should result in catches being less variable within strata compared to between strata if they are to be effective. This can be evaluated using the methods discussed in Francis (2006) for evaluating design efficiency in terms of stratification and allocation components. This approach would be a useful post-survey evaluation tool for determining for what species the strata were more or less effective.

The basic application of the stratified random design uses strata and allocation schemes to increase the precision of the survey estimates. Design-based surveys can be cast into a missing data structure where a limited number of sites are observed, and the fish abundances at the sites that were not trawled are estimated based on observations at the trawled sites. In a sense, the stratified survey design predicts catch-rates at the non-sampled sites by the mean for sampled sites in that stratum. If the relationships between site characteristics (temperature, depth, bottom type, etc.) and fish abundance are known, they could be used to predict the abundance at the non-sampled sites with perhaps more precision than simply using the stratified mean. The use of covariates in survey sampling has been discussed in Smith (1990), Valliant et al. (2000). and Särndal et al. (2003). Software to construct the proper design-based estimates are available in the R-package survey (Lumley 2004, 2011).

iii. *Comment on the method used to allocate stations to strata, station density, distance between stations, and the two-phase survey design, including appropriate levels of phase 2 sampling.*

The allocation method has been peer-reviewed and researchers at NIWA have a great deal of experience using the method in the field. The west coast survey has a smaller total sample size than the east coast survey with many strata only having 3 stations in total, and in at least one instance (2011) the survey ended before any phase 2 samples were allocated.

This two-phase allocation method will result in a biased estimate of the stratified mean but this bias will decrease as the proportion of samples allocated to phase 1 increases. The current practice according to the survey reports is to allocate 80% of the total sample size to the phase 1 survey. The bias of the mean could be avoided by using the Rao-Blackwell estimates given in Thompson and Seber (1996, see also Smith and Lundy 2006) but this method may not easily provide the same features as the current one in terms of determining compromise allocations over the main species being targeted by the survey.

While target CVs are being met in most cases, the Panel recommends routine evaluation of the efficiency gains for first and second phase samples after the survey has been completed. These results may help evaluate the adequacy of current levels of first and second phase sampling.

The precision desired for the estimates will also be a function of how the surveys will be used to meet the management objectives. If survey-based confidence intervals are going to be used to evaluate the probability of dropping below soft or hard limits, then it is possible that more precise estimates may be required (see Smith 1997 or Schnute and Haigh 2003 for bootstrap methods for constructing confidence intervals for stratified random estimates.)

iv. *Is the level of biological sampling appropriate to achieve acceptable levels of precision on estimates of catch-at-age and age-at-maturity? Do length and age frequencies track between surveys? Is survey frequency adequate to allow for this to be determined?*

The current practice is to combine all of the age information from a survey into one age-length key. This practice may result in smoothing over possibly different spatial relationships between age and length due to different age classes/life history stages residing in different parts of the survey area. An alternative method of constructing age-length keys that incorporate these spatial differences is to weight age data by the length frequency at the station level. A fuller discussion of this approach can be found in the report of the ICES Workshop on methods to evaluate and estimate the precision of fisheries data used for assessments (WKPRECISE)[3].

There was limited evidence for tracking cohorts in the length frequencies presented to the Panel and no formal evaluation using a model. The Panel will expand on this discussion below.

v. *What are the inherent assumptions in the survey design (e.g., catchability, selectivity)?*

The basic assumption of the survey design is that the survey index is proportional to the population abundance. In addition, there is the assumption that the species densities and species compositions are the same on trawlable and untrawlable grounds. The Panel recommends that the latter assumption be tested, given the large amount of foul ground in some of the strata, possibly through acoustical methods, or through use of some other form of gear that can be deployed on both the trawlable and untrawlable areas to catch the target species. Detailed position records for commercial fishing activities, available on the new catch recording forms, could also provide an opportunity to identify vessels able to work within the defined areas of foul ground and to compare their catch rates by species in these areas compared to the surrounding areas that are covered by the trawl survey.

vi. *Comment on other strengths/weaknesses of the design if not covered in the above?*

All are covered above.

vii. *Can the design be improved to obtain better species coverage?*

This would have to be evaluated by mapping out catches for each species over the survey time series, evaluating the current strata boundaries for each species and obtaining spatial information from the commercial fishery.

viii. *Can the design be improved to make it more cost effective?*

Improvements to make the design more cost effective are dependent on management priorities.

ix. *Review target species. Are others more appropriate? Is the stratification appropriate?*

The Review Panel assumes that the target species identified for the surveys reflect management priorities together with being species best sampled with a trawl. Otherwise the Panel is unable to assess if other species should be added as targets. The Panel was given documentation on the review for non-target species for the west coast survey which concluded that the full time series of biomass estimates (and CVs) be included for all the species.

Given that the current design was put in place for the target species, changing the design to accommodate other species should be carefully considered to avoid disrupting the time series for the original target species.

x. *Are there issues with the survey timing?*

3 http://www.ices.dk/reports/ACOM/2009/WKPRECISE/WKPRECISE%20Report%202009.pdf

There are no issues, unless seasonal and ontological movements differ from year-to-year.

xi *Comment on what needs to be done in preparation for a replacement for RV Kaharoa (estimated further 10 years lifespan) – what inter-calibration design might be considered?*

The Review Panel recommends that the design of any inter-calibration experiments take into account similar international experiences, documented by NEFSC (2007), Miller et al. (2010), ICES (2005), Pelletier (1998), Cadigan *et al*. (2006), and Fowler and Showell (2009).

It is desirable to incorporate all changes to gear, protocols or other survey operational details simultaneously with the vessel change, and reflect the combined changes in a single calibration coefficient. Experiments may be carried out as side-by-side tows during the course of normal surveying, or as dedicated tows in areas of known high fish concentration. Priority species should be identified, to ensure that sample sizes for those species are adequate to estimate coefficients with some certainty.

3. Post Survey Analysis

i. Review and comment on the analysis of length and catch-at-age data from the surveys and how they can best be used to monitor the fisheries (e.g., is development of recruitment indices possible and desirable?)

Length compositions from survey data are themselves well-estimated. The Panel recommends undertaking a formal modal analysis of length composition data, to determine if recruitment or cohort signals can be followed through the length compositions over time or if pre-recruit age classes can be distinguished from recruited fish. This could allow an analysis of whether patterns of increased recruitment are reflected in increased recruited biomass in subsequent years. Statistics such as maximum length and mean length above the size at recruitment to the fishery can reflect recruitment strength, but may also reflect fishing mortality history.

ii What modifications to the existing analyses, or new analyses, would make the survey results more useful to address the management objectives?

Interpreting survey trends using simple models

Fishery management advice for stocks covered by the east coast South Island and west coast South Island surveys (ECSI / WCSI) can potentially be given on the basis of simple trends in survey indices relative to proxies for MSY-compatible reference points, on their own or in combination with fishery CPUE trends where appropriate. If individual stocks become more valuable as fishery targets, a demand may arise for analytical assessments providing direct estimates of biomass, recruitment, fishing mortality and associated biological reference points, and forecasts of future fishing opportunities.

A draft initial application of "reduced" stock assessments (which omit age- and/or length-composition data and ignore recruitment variation) to red gurnard (GUR3) and elephant fish (ELE3) (Francis and Dunn 2012) was presented to the Review Panel and showed that the assumption of no recruitment variation was inconsistent with the available data. In particular, for the recent upward trends in both catch and biomass indices to be true there must have been a recent substantial increase in recruitment for these stocks. This implies the need for analytical methods that include recruitment dynamics, which would require some form of data to quantify annual recruitment variability.

Models including recruitment information

Currently most of the ECSI and WCSI survey stocks have good length composition data from the surveys, but the Review Panel was only shown age composition data for a few stocks (e.g. west coast giant stargazer and red gurnard). However, some stocks show length modes that could represent pre-recruit and recruiting year classes, presenting a possibility to separate out the survey length frequencies

into one or more pre-recruit groups and a combined group of post-recruits. Cross-validation of length modes and ages would be necessary using analysis of some otoliths or other age structures. This would allow modelling of data on pre-recruit and post recruit biomass components and fishery landings for stocks with only length data from the surveys. An issue with this approach is the biennial (or longer interval) nature of surveys which reduces the information on recruitment, which would ideally require separating out at least two length modes of pre-recruit fish.

Extension to full stock assessment methods

For stocks with no or few age composition data, an extension of the simple method described above is to use CASAL or Stock Synthesis to fit length composition data conditional on natural mortality, growth curves, standard deviation of length at age and other input parameters required by the models. This would require sufficient additional data on fishery landings and length/age compositions. In practice, data for such stocks may at present be too limited to support sophisticated models. However, if it is considered that such models may be needed in future, attention should be given to building the necessary input data and parameters. Some examples of CASAL applied to rig in FMAs 3 and 7 were available to the Review Panel and highlighted some of the issues and data needs for such methods.

Indirect estimates of fishing mortality rates

Analyses of fishing intensity or examination of commercial effort trends can be combined with catch/biomass ratios to evaluate trends in relative fishing mortality rates. That information, combined with results of yield-per-recruit analyses can provide additional forms of MSY-compatible biological reference points and proxies of stock status for management.

Technical interactions

In terms of fishery technical interactions, survey data can be analysed to determine if there are common trends in abundance and catch:biomass index ratios among stocks caught together. Species composition and spatial distribution of assemblages based on survey data can be compared with those in the commercial fishery to determine the extent of technical interactions, if information is available.

4. Alternative ways to get accurate information for informing management decisions.

i) What alternatives are there from a science perspective?
ii) What are the advantages/disadvantages and costs/benefits of using more data poor methods such as CPUE analysis, catch sampling, etc. over a trawl survey?

Fishery CPUE data

Standardised fishery CPUE series are given widely in New Zealand stock assessment reports as indicators of stock trends, on the assumption that CPUE is proportional to biomass, and may be presented alongside survey indices of abundance to validate this assumption.

An advantage of standardised CPUE data, given accurate records, is the availability of catch-rate figures for very large numbers of trips and hauls over large areas and throughout the year. The data are easily understood and evaluated by fishers. A disadvantage is that fishery CPUE may not vary in direct proportion to biomass (Restrepo *et al*. 1998) if fishing patterns change in response to fish abundance, species composition and management actions. This means that using soft or hard limits as a fraction of a "conceptual proxy" for B_{MSY} based on CPUE during an historical period when both CPUE and catches were relatively high (as proposed in the New Zealand Harvest Strategy Standard) could carry a high risk. Defining a hard limit as lowest (smoothed) CPUE that the stock has recovered from, and setting an appropriate soft limit in relation to this, may be a safer guideline for managers. This approach has been adopted for some data-limited stocks in the US and Canada.

The east and south coast South Island trawl surveys provide the possibility of monitoring the relationship between fishery CPUE and biomass in these areas, provided the CPUE data are partitioned and standardised in a way that provides the most direct comparison with the survey indices for recruited fish. This can identify and quantify "technology creep" or non-linear relationships between CPUE and biomass. The combination of standardised fishery CPUE (expected to be relatively precise but with potential bias in trends) and periodic trawl surveys (poorer precision but designed to give unbiased trends) may prove effective for informing management decisions.

ICES (2012)[4] gives an alternative approach to inform management decisions for stocks that have survey indices or other indicators such as reliable CPUE and mean length in the catch, but no analytical assessment (ICES category 3 stocks). The ICES method calculates a CPUE -adjusted, status-quo catch (a harvest control rule) based on a comparison of the two most recent CPUE values with the three preceding values, combined with recent catch or landings.

The New Zealand HSS allows for a "conceptual F_{MSY}" for stocks with no analytical estimates of *F* reference points. In cases where an estimate of relative biomass exists (e.g. from trawl surveys or models incorporating these), it may be possible to define a fishery catch: relative (exploitable) biomass ratio that reflects an appropriate historical period when both catches and biomass were high, and to use this catch/relative biomass ratio as a fishing mortality target. The fishing mortality proxy is the ratio of the annual catch to the average or mid-fishing season biomass index during the fishing year. The Review Panel recommends comparison of trends in catch:biomass index ratios for stocks taken in mixed fisheries, as a simple method of examining possible trends in fishing mortality in relation to trends in fishing effort.

Tagging studies to estimate mortality

In the absence of direct estimates of fishing mortality from an analytical assessment, tagging programmes could be set up to estimate total mortality from tag returns, using a design-based approach allowing proper weighting of the data to give least-biased estimates of mortality. Sufficient rewards should be provided as incentives for tag returns (including double tagging to evaluate return rates), and fish would need to be collected from short tows in shallow water to minimise mortality. Tag returns would also help to understand stock structure and mixing, and validate growth rates from otoliths or spines.

Fishery selectivity

Management decisions for data-limited stocks may extend beyond the setting of TACs to include improvements in fishery selectivity, reduction of discarding of undersized fish and spatial management. Comparisons of fish community and size structure data from trawl surveys with distribution of commercial fishing activity will highlight the potential for discarding given mesh size in use, and the mix of species with different vulnerabilities to exploitation related to their life history characteristics. Sufficient sampling of fishery catches to estimate size composition would be necessary, which would also support possible future development of analytical assessment methods such as CASAL or Stock Synthesis III which can handle mixes of length and age composition data. Fishery selectivity patterns are also needed for calculation of yield-per-recruit reference points such as $F_{0.1}$ or $F_{x\%SPR.}$

5. Getting more out of the surveys

i. Using the survey data for "reduced" and full stock assessment approaches.

4 http://www.ices.dk/advice/Data%20Limited%20Stock%20Methods%20Implementation%20DRAFT.pdf

ii. The use of length frequency information to validate ageing techniques and interpret changes to age class changes.

These topics are covered under ToR 4 above.

iii) Development and use of environmental indicators.

Worldwide, there is considerable impetus to build more complete knowledge of human pressures and impacts on marine ecosystems and component populations, to support integrated management of the wide range of marine activities. This is also explicit in the New Zealand Government's goal and outcomes for the fisheries sector set out in *Fisheries 2030* and the 2011 draft National Fisheries Plan for Inshore Fin Fish. The draft plan identifies use outcomes related to economic, social and cultural benefits of fisheries and environmental outcomes related to sustaining the capacity and integrity of the aquatic environment, habitats and species at levels that provide for current and future use. These include conserving the biodiversity and the function of ecological systems, including trophic linkages, protecting habitats of special significance to fisheries, reducing or avoiding adverse effects on protected species and addressing impacts, including cumulative impacts, of activities on land, air or water on aquatic ecosystems. It is internationally recognized that multidisciplinary surveys at sea on research vessels provide the best platform for collecting many of the kinds of information needed to address such goals. Surveys provide the controlled structure/design to collect quantitative data. A presentation to the Review Panel (SITS-REV-2012-10: Tuck, Cole and Devine) on ecosystem indicators for New Zealand fisheries examined a wide range of indicators derived from existing surveys. The Review Panel supports further development of these approaches and that New Zealand scientists continue to contribute to similar international initiatives within bodies such as ICES.

The routine collection of oceanographic data such as sea temperatures, acoustic back-scatter and fluorescence during and between trawl stations may also prove valuable for explaining observed changes in trawl catch rates and choosing between alternative hypotheses, as was demonstrated at the review meeting when temperature data were examined in relation to a period of unusually low survey catch rates of hoki.

6. Conclusions and recommendations

i. *Formulate conclusions and recommendations on the key aspects of surveys listed above, including identification of likely consequences of any suggested changes on time series comparability.*

Conclusions

- The design of the East and West Coast South Island trawl surveys follows best practices.
- Survey frequency and cost-effectiveness depend on management needs. Simulation-based Management Performance Evaluation is the appropriate method to evaluate tradeoffs in frequency, cost and statistical performance.
- Further analysis is needed to interpret if biomass indices reflect population dynamics, and to develop proxies for MSY reference points.
- Survey indices of abundance may serve as a benchmark to interpret trends in commercial fisheries CPUE.
- The trawl surveys are ideal platforms for meeting additional management objectives, including development and use of environmental indicators.

Recommendations

- Analysis should be undertaken to determine if observed trends in biomass and length/age structure represent coherent population dynamics signals; for example, if stock biomass is responding predictably to changes in recruitment and/or fishing pressure.

- Although target CVs are being met in most cases, routine evaluation of the efficiency gains for first and second phase samples should be carried out after the survey has been completed. These results may help evaluate the adequacy of current levels of first and second phase sampling.

- The assumption that the species densities and species compositions are the same on trawlable and untrawlable grounds should be tested using given the large amount of foul ground in some of the strata.

- The design of any inter-calibration experiments should take into account similar international experiences.

- The Panel recommends undertaking a formal modal analysis of length composition data, to determine if recruitment or cohort signals can be followed through the length compositions over time or if pre-recruit age classes can be distinguished from recruited fish.

- The Panel recommends comparison of trends in catch:biomass index ratios for stocks taken in mixed fisheries, as a simple method of examining possible trends in fishing mortality in relation to trends in fishing effort.

ii. *Provide advice on alternative ways of meeting the management objective if surveys are not providing a reliable mechanism.*

See text above.

iii. *Provide advice on the consequence of using alternative data gathering mechanisms for meeting the management objective if the surveys are stopped.*

See text above.

iv. *Any other issues or potential solutions that the panel believes it should mention to the Working Group.*

The Panel has no additional comments.

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