Review of National Bycatch Reporting

Extension of: "Benchmarking Australia's National Fisheries Status Reporting System"

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IC Independent Consulting

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In submitting this report, the researcher has agreed to FRDC publishing this material in its edited form.

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Executive Summary

Over the past decade or so, many jurisdictions throughout the world have developed systems that regularly report on the status of fish stocks. In more recent times, jurisdictions are realising that it is just as important to also report on fisheries bycatch (most usually defined as non-targeted catch) and especially that portion which is discarded. A key reason for this is that discarded organisms (because they are too small, protected, undesired, outside a quota or a TAC, etc.) remain public property throughout the entire capture and discarding process. Public reporting on their status should therefore be just as important (if not more so) as reporting on exploited stocks.

One of the key issues that arose during the preparation and reviews of the recent "Status of Key Australian Fish Stocks Reports" was that there exists no system in Australia for reporting on bycatches or discards. That is, there currently exists no mechanism by which the public, governments, stakeholders or international agencies can assess Australia's performance in dealing with bycatch. Due to this gap, FRDC recently commissioned this extension to FRDC 2013/233 whose Terms of Reference are:

- Provide a brief summary of the US National Bycatch Report and other overseas bycatch reports;
- Investigate current and future FAO initiatives in this area;
- Benchmark the current Australian situation on bycatch reporting against the above; and
- Recommend a clear pathway towards an appropriate national system.

Summaries of the US National Bycatch Report and other overseas bycatch reports

Only 4 instances were found where international jurisdictions have provided consolidated reports on fisheries bycatch and discards, two by the United States (an inaugural national report and its first update) and two decadal global reports by FAO.

The US National Bycatch Report was the result of a large, 5 year undertaking by dozens of NMFS staff, completed in 2006 with estimates mostly based on data collected in 2005. In each the US's 6 fisheries regions, bycatch ratios were determined for individual fish stocks (*stock bycatch ratios*) and individual fisheries (*fishery bycatch ratios*). The report provides: (i) a list of the 274 federal, state, international, and indigenous commercial fisheries in the US, identifying management authorities, gear types, target species and bycatch data sources; (ii) an evaluation of bycatch data sources and estimation methods for 152 federal commercial fisheries (46% of which were determined to have high-quality information); (iii) an estimated overall national bycatch ratio for fish of 17%; (iv) individual bycatch estimates for 81 federal commercial fisheries; (v) stock-level bycatch estimates for 480 fish, 54 marine mammals, 12 sea turtles, and 28 seabirds; (vi) the identification of 396 key stocks for continued monitoring; and (vii) 120 recommendations to improve data collection and estimation of bycatch.

Despite the size of this undertaking, the US National Bycatch Report could be argued to not be a true **national** report as it did not cover 122 state, international and indigenous fisheries

nor any recreational fisheries (however, there is a stated intention to eventually include these other fisheries in future editions). It nevertheless covers a large majority of the commercial fisheries in the US and provides an excellent starting point for a truly national system.

Of particular interest to countries who may be considering a bycatch reporting scheme, are the performance measures and tracking tools developed and described in the US report. These are: 1) the **tier classification system**, used to monitor the quality of bycatch estimates; 2) a designated list of **key stocks**, used to monitor particularly important bycatch trends over time; 3) a group of **fisheries of focus**, that will be tracked because they have one or more of the above key stocks as bycatch, and/or have high total levels of fish bycatch; and 4) **fishery bycatch estimation improvement plans** developed for each of the above fisheries of focus. These tools are intended to allow NMFS to track how they are improving the effectiveness of their bycatch monitoring programs, and the success (or otherwise) of their bycatch reduction programs.

The US National Bycatch Report was the first of a series of scheduled reports intended to document bycatch in US fisheries over time. This schedule involves online updates every 2 years with comprehensive reports done every 6 years. In 2013 the first online update was completed which included data for 2010. There were several improvements in this update with individual regions contributing additional data sources and estimates to those provided in the original report. Also, whilst the first edition had a 6-year lag between data collection and publication, the first update only had a 3 year time lag.

The UN FAO first commissioned a global report on bycatch and discards that was published in 1994 by Alverson et al. called “A global assessment of fisheries bycatch and discards”. Data for the report were retrieved from literature searches, augmented by direct contacts with numerous entities. For most estimates of discards, Alverson et al. assumed that the rate of discard was a function of landings by a given target species. They were meticulous in describing the many factors that influenced their estimates and consistently stated that the estimates were, at best, provisional “best guesses”. Despite the potential errors, biases and assumptions, this report yielded the first useful global estimates of bycatches and discards. It provided a yearly mean global estimate of 28.7 million mt of bycatch and 27.0 million mt of discards, based on a target catch of 77 million mt (a discard ratio of approx. 35%).

A decade after Alverson’s report, FAO considered it timely to review global bycatch and discards by commissioning an update that was completed by Kelleher in 2005. Kelleher (2005) used a different approach to estimate discards than Alverson et al. by adopting a fishery-by-fishery approach, based on the premise that discards are a function of the landings of a fishery, rather than a function of the landings of a particular species. The information was compiled from the scientific literature, published national and other reports and contacts with experts in various organisations. Kelleher’s estimate for global discards was 6.8 million tonnes with total recorded landings of 78.4 million tonnes - a discard ratio of approx. 8%, less than half the lower end of Alverson et al’s. Kelleher concluded that such a reduction could be due to: (i) greater utilisation of bycatch species for aquaculture and human consumption; (ii) adoption of more selective fishing technologies and methods; (iii) a decline in the intensity of fishing for some species that had high bycatch rates; (iv) a variety of management actions that: prohibit discarding in some countries, set bycatch quotas,

impose time/area closures, establish marine protected areas, and no trawl zones, etc.; and (v) more progressive attitudes by fishery managers, user groups and society towards the need to solve discarding problems.

Of particular interest are the country-specific discard estimates provided by Kelleher and particularly that for Australia (55.3%) which compares (unfavourably) with that of the US (21.7% - now reduced to 17% in the light of the above US National Bycatch Report) and 10.2% of Canada. Intuitively, the estimate for Australia is too high (no doubt due to the limited datasets Kelleher has access to). It is doubtful that Australia's fisheries discard more than they retain and, more likely, our discard ratios would be similar to that for the US and/or Canada because we use similar fishing techniques. But in the absence of any better overall discard estimate, Australia is, unfortunately currently "stuck" with such an inflated number.

Late last year FAO staff recognised that it was approaching 10 years since the Kelleher (2005) report on global discards and 20 years since the Alverson et al., (1994) report. It was considered prudent to maintain this decadal reporting schedule and therefore timely to begin discussions regarding the next report on global bycatch and discards, particularly with regard to the scope of such a report, its methodology, an appropriate team to do the work and potential funders. A formal prospectus for funding such an initiative is being developed with the first workshop scheduled for November 2014.

Benchmark the current Australian situation on bycatch reporting against the above

Benchmarking Australia's bycatch reporting system against the above reports is a relatively simple exercise - because Australia simply does not have any such system and therefore has no "mark" on any such "bench"!

The closest Australia has come to provide any sort of synthesis in this area is a recently completed one-off report for Commonwealth-managed fisheries by Tuck et al, (2013). For each of 6 key Commonwealth fisheries, this report documented the data collected, the bycatch management processes that had been implemented and temporal trends in observations of bycatch and its composition. While this report was a sound attempt for Australia's Commonwealth-managed fisheries, such fisheries only represent a small fraction of Australia's fishing effort. Our 7 state and territory jurisdictions manage thousands of commercial vessels (and millions of recreational anglers) - the bycatch from which was not covered in that report. And these latter jurisdictions have not produced a consolidated bycatch report of their fisheries.

Like the United States, there exist significant sources of bycatch data throughout Australia's fisheries, albeit not as extensive as the US's impressive data sources. Australia's bycatch data are in the form of numerous ongoing and one-off observer programs, logbook reports for various commercial fisheries, fishery dependent surveys and recreational creel studies done by state and federal agencies. What is lacking is any consolidation and synthesis of such information in the form of a nation-wide, repeatable, reporting system, by which Australia can (i) identify the current situation with regard to bycatches and discards; (ii) track through time, using appropriate metrics, our efforts to manage bycatch and reduce discarding; and (iii) contribute to international efforts to report and track bycatch and discarding globally. Of course a corollary to such a system will be the provision of better

estimates of our national discarding rates which, as we saw earlier, should be a lot less that the current FAO estimate of 55.3%.

Recommend a clear pathway towards an appropriate national system

In developing a pathway towards an appropriate national system for bycatch reporting in Australia, it is appropriate to consider the approach used by NMFS. As for the US report, the desired outcome from an Australian bycatch reporting system should be the establishment of a repeatable (every 5 years or so), transparent system tied to the current SAFS reporting process by which governments, the public and other stakeholders (including commercial and recreational fishing sectors, environmental NGOs, etc.) can track and assess the progress (or otherwise) in the management of bycatch and discards from our fisheries.

A logical set of steps is required to deliver this outcome:

- Firstly, to determine where we sit nationally with respect to bycatch and discard data, we should initially identify all available reports/papers/unpublished datasets on bycatches and discards from as many fisheries in Australia as possible;
- Next we should assess these datasets and documents and apply a quality score for each so we can assess their relative value and accuracy. A summary "quality" metric should be applied and be available for comparisons with future reports;
- Analyse the information gathered to calculate summary estimates of bycatches for fisheries, species, jurisdictions and the nation. From this analysis we should identify the positives and negatives in our datasets. That is, using a risk-based approach, we should identify those fisheries and fishing methods where we have adequate information, those for which we do not, and any fisheries/methods which may prove useful as surrogates/indicators for particular types of fisheries/methods.
- Using the lessons learned from the above, develop templates, reporting processes, key methods/fisheries/species/surrogates/indicators/etc. to be used in subsequent repeats, and therefore provide a system of reporting to be used as an adjunct to the current SAFS reporting system.
- Develop an initial first bycatch "report card" for Australia using an appropriate traffic light system based on the above analysis and so compile Australia's First National Bycatch Report.
- Repeat this process periodically as a part of SAFS and as a mechanism to inject data into the Fishery Health Check system currently under development. The US bycatch reporting system involves a schedule of online updates every 2 years with a full report every 6 years, and the FAO process is a decadal one. Australia should probably try to aim for updates every 5 to 10 years – which would allow for reasonable regularity and also sufficient time for improvements in bycatch management to take effect.

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The author would like to thank Petri Suuronen and Frank Chopin (UN FAO) and Bill Karp (NOAA Fisheries) for helpful discussions regarding this project and Patrick Hone and Crispian Ashby for their support of the project. Crispian Ashby also provided very useful comments on the draft report.

Introduction and Background

In the past decade or so, it has become accepted (and indeed, expected) that governments should regularly report to the public and other stakeholders regarding the status of their fish resources and the fisheries that exploit them. Public reporting is especially important because the public are the owners of fisheries resources – right up to the point where fishers (commercial and recreational) legally catch and retain fish, at which time it becomes their property, to sell, eat or discard. In recent years we have seen numerous jurisdictions throughout the world (including Australia) provide status reports for these fish stocks.

For organisms caught as bycatch – most usually defined as non-targeted catch - and especially that portion which is discarded, this need for public reporting is even more appropriate because the public ownership over such organisms is even greater. That is, fish and other organisms that are discarded (because they are too small, protected, undesired, outside a quota or a TAC, etc.) remain public property throughout the entire capture and discarding process. Reporting to the public by governments (who have stewardship over such resources on their behalf) on the status of discarded organisms should therefore be just as important (if not more so) as reporting on exploited stocks.

Australia is regarded as among the world's leading nations in terms of fisheries management and the science that underpins it, so how we report on our performance in managing our fish stocks, bycatches and discards is therefore crucial, not only to satisfy the many audiences requiring this information, including the public who own these things, but also to maintain our international reputation.

A recent initiative developed a national reporting scheme for many of Australia's key exploited fish stocks. This yielded the document "Status of Key Australian Fish Stocks Reports" (Flood et al, 2012) and work is now underway on the next version of that report. One of the key issues that arose during the preparation and subsequent reviews of that report (from AFMF, DAFF, DoE and others) was that there exists no national system for reporting on bycatches or discards. That is, there exists no mechanism by which the public, governments, stakeholders or international agencies can assess Australia's performance in dealing with bycatch. A new project funded by FRDC (Fishery status reports: health check for Australian fisheries) is developing categories of information by which Australia's fisheries will be able to be assessed. Obviously, information on discards will be one of the key categories of data to be included in such a system (Hobday, pers. comm) yet there currently exists no simple way to obtain such information for most of our fisheries, nor any system in place to regularly provide such data. Further, in another project that benchmarked Australia's fisheries reporting against international systems (FRDC 2013/233) it was also recommended that Australia should develop a system to include reporting on bycatches, discards, TEP interactions and other environmental impacts of fisheries.

Whilst some attempt to do this was recently completed for Australia's Commonwealth fisheries (Tuck et al., 2012), this only included information from the approximately 325 fishing vessels that are managed by the Commonwealth government. Australia's state and territory jurisdictions manage several thousand commercial fishers and millions of recreational fishers, the bycatch from which was not captured in that report.

Due to this clear gap, FRDC recently commissioned this extension to FRDC 2013/233 (Benchmarking Australia's national fisheries status reporting system) whose Terms of Reference are:

1. Provide a brief summary of the US National Bycatch Report and other overseas bycatch reports;
2. Investigate current and future FAO initiatives in this area;
3. Benchmark the current Australian situation on bycatch reporting against the above; and
4. Recommend a clear pathway towards an appropriate national system.

ToR 1 - Summaries of the US National Bycatch Report and other overseas bycatch reports

In searching for information to summarise under this ToR, only 4 instances were found where international jurisdictions have attempted to provide a consolidated report on fisheries bycatch and discards, two of which were by the United States (their inaugural national report and its first update) and two by the UNFAO (their two decadal global reports). The PI was unable to locate any other consolidated report on bycatch or discards for any other jurisdiction, although he was advised that Canada, New Zealand and the EU are planning to prepare such reports.

The US National Bycatch Report

Background

The US National Bycatch Report (NMFS, 2011) was initiated in 2006 and completed in 2011, with bycatch estimates mostly based on data collected in 2005. It is the first nation-wide compilation of estimated bycatches for the federally-managed commercial fisheries of the United States and, indeed, for any country. It describes sampling and estimation methods, a framework for evaluating the quality of bycatch estimates, and performance measures for monitoring improvements in the quality of bycatch data and estimates throughout time.

The report was done because: (i) reducing the bycatch of fish, marine mammals, sea turtles and seabirds is required under the guiding legislation of the US's National Oceanic and Atmospheric Administration's National Marine Fisheries Service (NMFS); and (ii) NMFS decided that the first step in reducing bycatch was to produce an accurate characterisation of current bycatch levels as a benchmark for evaluating such efforts. Further, the report was done because it was noted that "understanding the amounts and types of bycatch in our nation's fisheries is an important component of ecosystem-based management, which seeks to account for the complex connections among organisms, including humans and their environment". The report is therefore the first in a planned series of national bycatch reports designed to track and report on efforts to monitor and reduce bycatch in the US. It is to "serve as a cornerstone, aiding NMFS in meeting our bycatch reduction mandates and stewardship obligations by identifying trends in bycatch, guiding policy, and setting priorities for bycatch data collection".

It is important to note that, despite its size and comprehensiveness, the report only contains bycatch estimates for the federally-managed commercial fisheries of the US. It does not include state, recreational, or international fisheries, so the bycatch data for some fisheries and species are incomplete. It could be argued that, as a result of this incompleteness, this report cannot be said to be truly **national**. However, it is important to note that the report covers a large majority of the commercial fisheries in the US (152 of 274) - with the remaining 122 fisheries being state, international or indigenous fisheries. It is therefore an excellent starting point for a truly national system and there is a stated intention to eventually include these other fisheries in future editions.

Methodology

A massive amount of work went into compiling the report over its 5 year gestation. The work was led by 3 senior staff of NMFS and involved 42 staff formed into "Bycatch Report Regional Teams" in each of the US's 6 fisheries regions (the Northeast, Southeast, Alaskan, Northwest, Southwest and Pacific Islands). These teams provided the actual data for the report and operated under the control of an 18 person National Bycatch Report Steering Committee. Two additional SeaGrant fellows also assisted in the development of the report.

Numerous workshops and conference calls among the National Bycatch Report Steering Committee led to the overall approach used to compile the report. The regional teams each collected data that were used for bycatch estimation within each region, some of which came directly from the fishing industry itself, such as fishermen's logbooks, but the majority came from the US's many fisheries observer programs (see Fig. 1). Using this information, in addition to data on fisheries landings, scientists in these regions generated estimates of bycatch at the fishery and species level. The quality and amount of available data and the methods used to estimate bycatch varied widely among regions, fisheries and species but, overall, a staggering 110 fisheries in the US have observer data with over 67,030 observer sea days used to provide bycatch information in the report (Table 1).

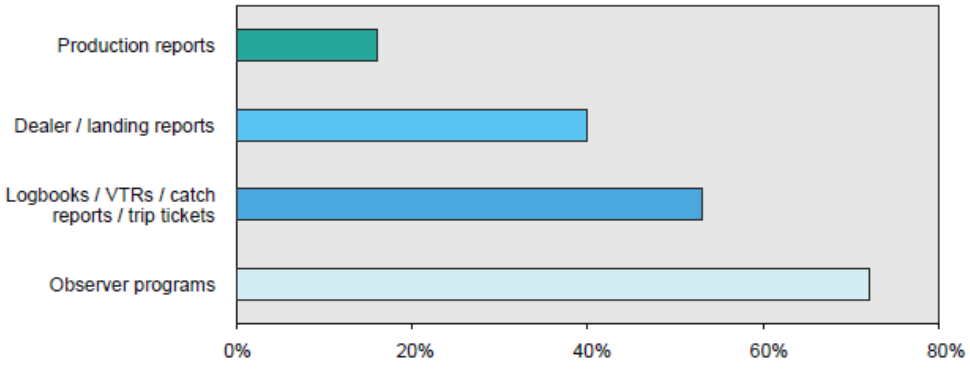

Fig. 1 – The main sources of data used to estimate bycatch for fisheries and species in the US national Bycatch Report. Data are from 2005, except for certain rare-event species that required data from a range of years. Note that the percentages do not total 100 because multiple data sources were sometimes used.

Table 1 – The sources of data used to develop the 2005 estimates of bycatch, by region and fishery

Region / # fisheries [a]	Fisheries observed [b]	Observed days at sea [c]	Fisheries with production reports /dealer reports [d]	Fisheries with logbooks / vessel trip reports / catch reports/ trip tickets [e]	Fisheries with production reports
Northeast / 63	47	11,381	27	42	
Southeast / 48	12	2,657		9	
Alaska / 77	27	35,683	27		25
Northwest / 30	11	6,184		9	
Southwest / 25	10[f]	499		10	
Pacific Islands / 31	3	7,099	7	10	
Total / 274	110	67,030	61	80	25

[a] Numbers of U.S. commercial fisheries included in the U.S. National Bycatch Report.
[b] Maximum number of fisheries observed, 2005 to present.
[c] Numbers of observed sea days are for calendar year 2005; totals for days at sea only, does not include observations of 663 permit samples.
[d] Production and Dealer (landing) reports are submitted by either dealers or processors upon landing of catch.
[e] Logbooks, vessel trip reports, catch reports, and fish tickets are all names for similar reports submitted by fishermen.
[f] One fishery listed as observed for the Southwest Region is a recreational fishery, and bycatch estimates are not included in the U.S. National Bycatch Report for this fishery.

In each region, bycatch ratios were developed for both individual fish stocks (*stock bycatch ratios*) and individual fisheries (*fishery bycatch ratios*) (see Fig. 2). The ratio is the simple calculation of bycatch divided by total catch (where total catch is bycatch plus landings). While other methods have been used to calculate a bycatch ratio (e.g. bycatch/landings or a weighted average), the US calculation was considered the best and most standard approach (and was also used by Kelleher 2005 – see later in this report). Bycatch ratios were not calculated for protected species because they were not landed. Further, a bycatch ratio was not calculated if either the bycatch or landings data were unavailable.

	Fishery A	Fishery B	Fishery C	Total stock bycatch
Stock 1	1	0	0	1
Stock 2	1	2	0	3
Stock 3	2	5	3	10
Total fishery bycatch	4	7	3	

Fig. 2 – Bycatch estimates were calculated at both fishery and stock levels (sample values are given here for illustration). The down arrow illustrates how bycatch estimates were calculated by fishery (e.g. the total of all stocks caught within fishery A); the right arrow illustrates how bycatch estimates were calculated by stock (e.g., the total amount of stocks 1–3 caught by all fisheries).

Results

The report provides: (i) a complete list of the 274 federal, state, international, and indigenous commercial fisheries in the US, identifying management authorities, gear types, target species and bycatch data sources; (ii) an evaluation of these bycatch data sources and estimation methods for 152 federal commercial fisheries (46% of which were determined to have high-quality information) - the remaining 122 state, international and indigenous fisheries were not included in the report nor were any recreational fisheries; (iii) an estimated overall national bycatch ratio for fish (bycatch/total catch) of 17% (a little lower than the estimate of 22% provided by FAO for the US in 2005 - Kelleher 2005); (iv) individual bycatch estimates for 81 federal commercial fisheries; (v) stock-level bycatch estimates for 480 fish, 54 marine mammals, 12 sea turtles, and 28 seabirds; (vi) the identification of 396 key stocks that will continue to be monitored over time for changes in bycatch levels (see below); and (vii) 120 recommendations on ways to improve the collection and estimation of bycatch for key fisheries. Table 2 and Figs. 3 and 4 provide examples of the sort of summary data produced. Detailed information on individual species and fisheries are given in the report for each region in a very large number of tables and figures and are not provided in this summary for the sake of brevity.

Table 2 - Total estimated fisheries landings and bycatches for each NMFS region. Data are generally from 2005, except for some rare-event species estimates for which bycatch data from a range of years may have been used. Weights are rounded to the nearest thousand pounds.

Region	Fish bycatch (lb)	Fish landings (lb)	Marine mammal bycatch (individuals)	Sea turtle bycatch (individuals)	Seabird bycatch (individuals)
Northeast	165,888,000	1,006,370,000	1,287	1,062	Not available
Southeast	682,691,000	219,086,000	233	10,671 [a]	186
Alaska	338,573,000	4,487,167,000	62	0 [b]	7,280
Northwest	25,564,000	332,396,000	37	0 [b]	106
Southwest [c]	Not available	—	242	1	Not available
Pacific Islands	8,556,000	23,000,000	26	38	197
Totals	1,221,272,000	6,068,019,000	1,887	11,772	7,769

[a] The Southeast sea turtle bycatch estimate includes mortality estimates from the NMFS 2002 biological opinion on the shrimp fisheries of the Southeastern United States (NMFS 2002). Since that time, effort in the shrimp fishery, and associated bycatch, has decreased markedly.
[b] Sea turtle bycatch has not been observed in the Alaska or the Northwest Regions.
[c] Southwest Region landings are not included because fish bycatch estimates from the region were not available.

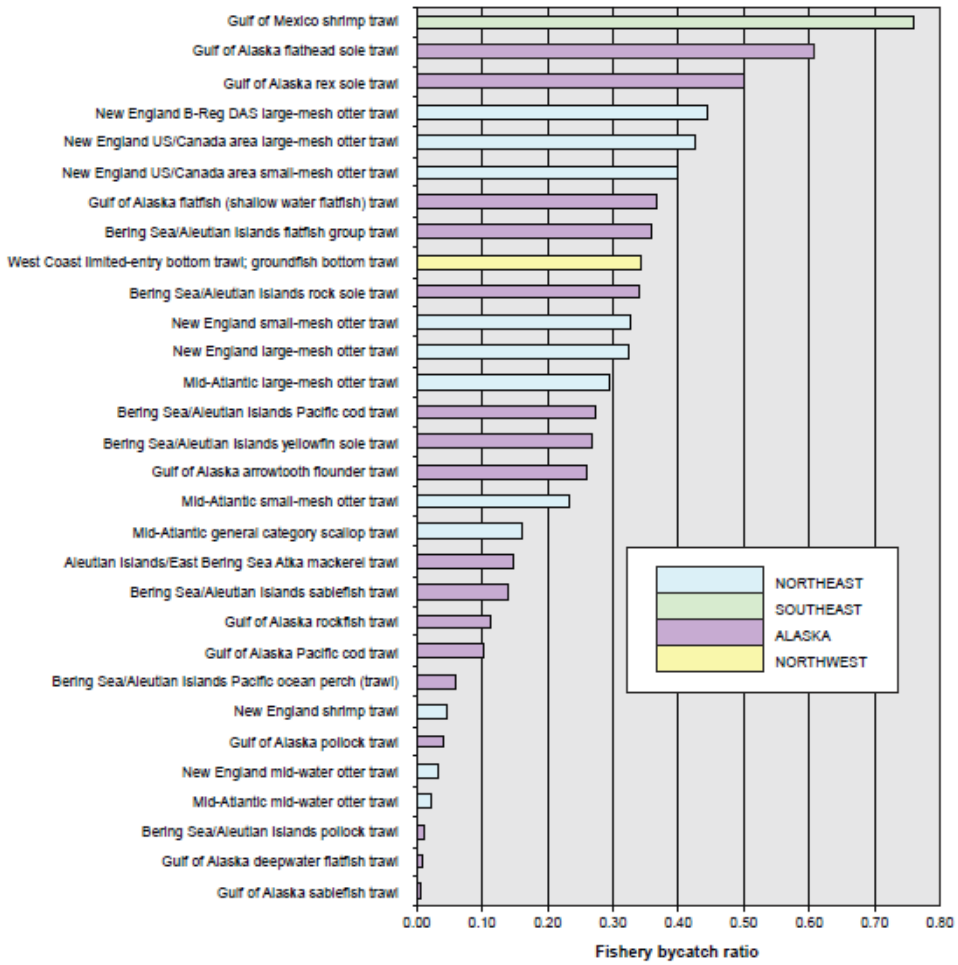

Fig. 3 - Fish bycatch ratios for U.S. commercial trawl fisheries by NMFS region.

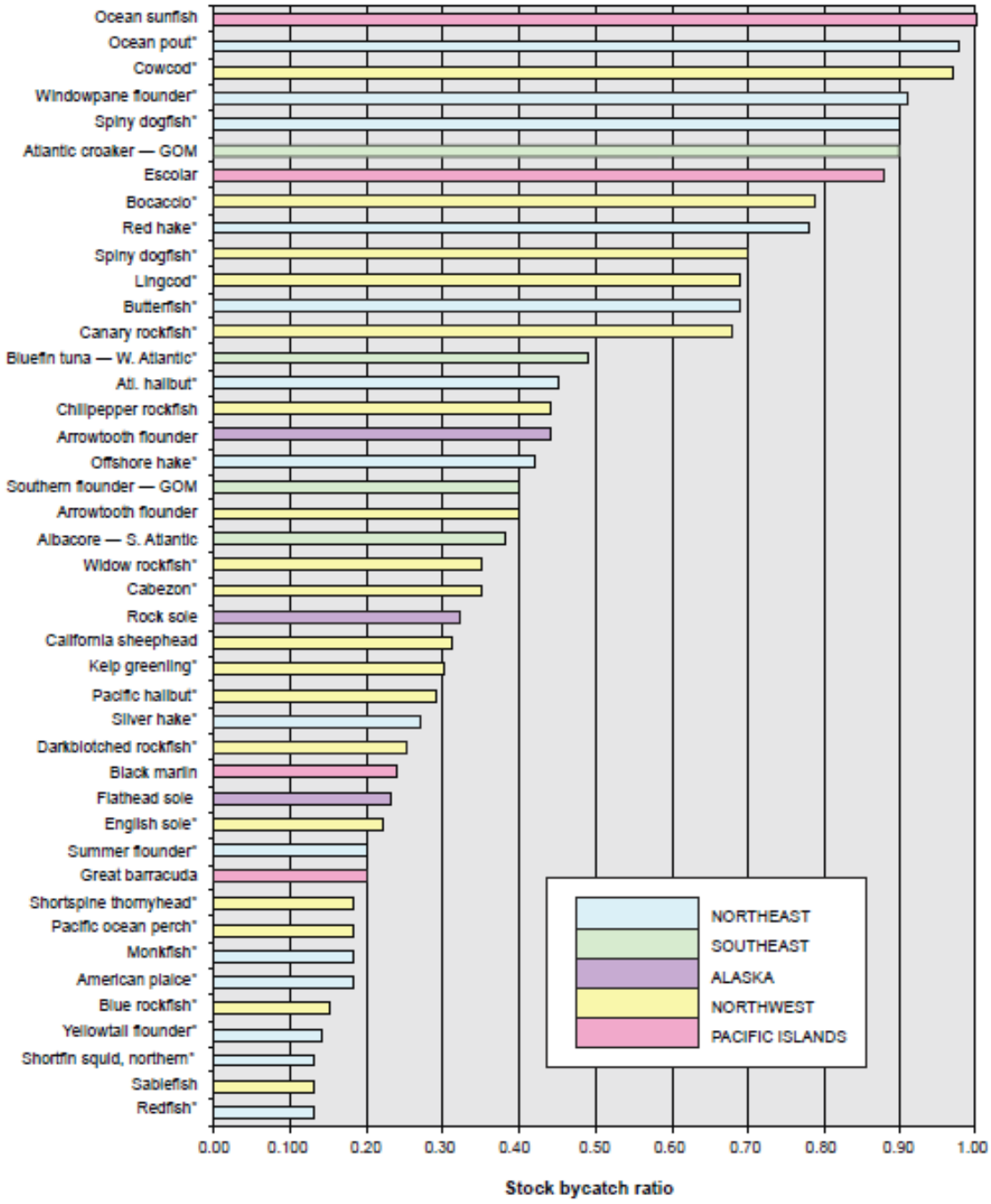

Fig. 4 - Fish stocks with fish bycatch ratios greater than 0.127 by NMFS region (2005 data). * indicates a key stock. GOM = Gulf of Mexico.

Performance Measures and Tracking Tools

Of the large amount of information provided in the US National Bycatch Report, of particular interest to other countries who may be considering a bycatch reporting scheme (like Australia), are the performance measures and tracking tools developed and described. These are: 1) the **tier classification system**, used to monitor the quality of bycatch estimates; 2) a designated list of **key stocks**, used to monitor particularly important bycatch

trends over time; 3) a group of **fisheries of focus**, that will be tracked because they have one or more of the above key stocks as bycatch, and/or have high total levels of fish bycatch; and 4) **fishery bycatch estimation improvement plans** developed for each of the above fisheries of focus. These tools are intended to allow NMFS to track how they are improving the effectiveness of their bycatch monitoring programs, and the success (or otherwise) of their bycatch reduction programs. These tools are summarized below.

The Tier Classification System

This system provides a measure of the relative quality of bycatch estimates within and between regions, categories of bycatch, stocks and fisheries. It involves a very detailed and prescriptive allocation of point scores for each data source against set criteria for the 400 sources of data used in the report (see Table 3). Note the very heavy weighting assigned to observer data in this scheme compared to industry-gathered data.

Table 3 - Criteria and scoring used to evaluate bycatch data quality and estimation methods in the US's tier classification system.

Tier Classification Criteria			Maximum Scores
Adequacy of Bycatch Data	Observer Data	Longevity of Observer Data	5
		Sampling Frame	3
		Sampling Design of Vessels/Permits/ Licenses	4
		Sampling Design of Trips	4
		Sampling Design of Hauls	4
		Spatial Coverage	2
		Temporal Coverage	2
		Vessel-Selection Bias	2
		Observer Bias	2
		Data Quality Control	5
		TOTAL	**33**
	Industry Data	**TOTAL**	**2**
	Supplementary Data	Data available as expansion factors for unobserved components	2
		Data available for stratification	2
		Data available for imputation	2
		Data available for model covariates	2
		Industry data verified	2
		TOTAL	**10**
	Database / IT	**TOTAL**	**2**
Quality of the Bycatch Estimate	Analytical Approach	Assumptions Identified, Tested, and Appropriate	10
		Peer Reviewed / Published Design	4
		Peer Reviewed / Published Analytical Approach	4
		Statistical Bias of Estimators	4
		Measures of Uncertainty	4
		TOTAL	**26**
TOTAL POINTS POSSIBLE			**73**

Each region, bycatch category, stock and fishery was placed into 5 tiers based on these scores as follows (Table 4):

Table 4 - Tier Descriptions

Tier	Score	Description
4	66-73	Bycatch estimates were available and were based on the highest-quality data and analytical methods.
3	49-65	Bycatch estimates were also generally available but higher quality data (i.e., data that are more reliable, accurate, and/or precise than those used in lower tiers) were utilized to compute these estimates.
2	32-48	Bycatch estimates were generally available. However, these estimates would have benefited from improvements in data quality and/or analytical methods (such as improved sampling designs, increased coverage levels, and peer review of methods). Where by-catch estimates were not available, methods are being developed.
1	1-31	Bycatch data were available but were generally unreliable (e.g., from unverified or potentially biased sources). In some cases, higher quality data were available but analytical methods had not been implemented.
0	0	Bycatch data-collection programs or estimation methods did not exist and, therefore, bycatch estimates were not available.

Summary results from the first use of the tier classification system is seen in Figs. 5 and 6. As improvements are made to bycatch data collection, and new methods for estimating bycatch are developed and implemented, the tier scores of individual fisheries are expected to increase.

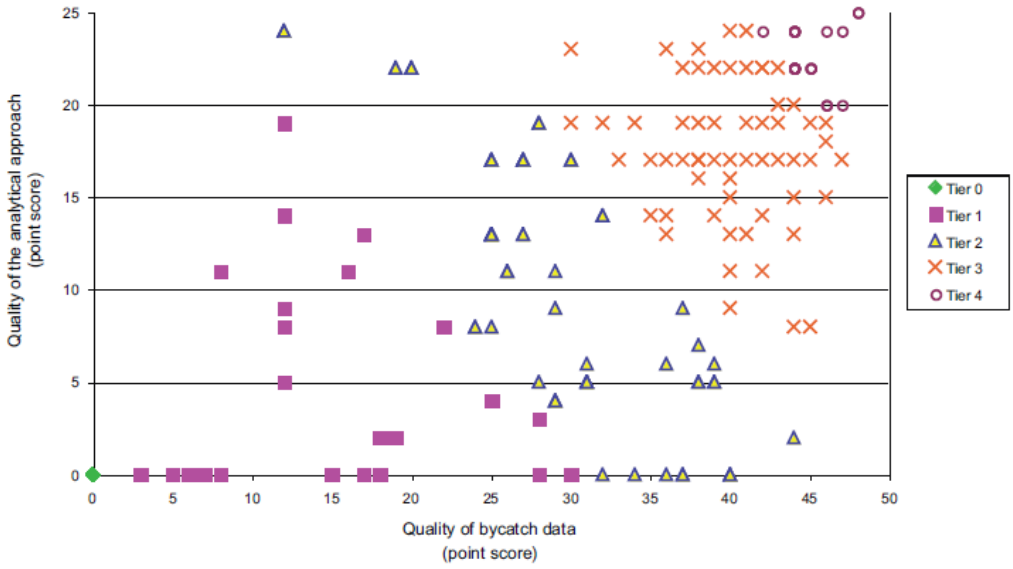

Fig. 5 - Quality of bycatch data and estimation method, and resulting tier classifications of fisheries included in the U.S. National Bycatch Report (*n* = 400).

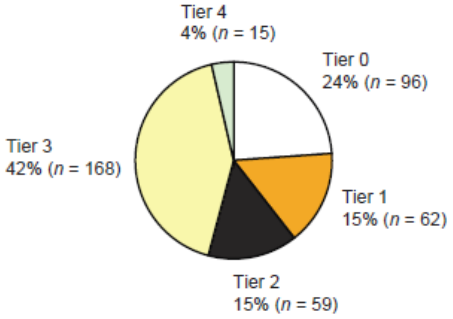

Fig. 6 - Distribution of tier scores for the quality of bycatch data and estimation summed across fisheries, regions, and bycatch categories. The total number of tier scores derived for the report was 400: fish (142) + marine mammals (129) + other protected species (129).

Designation of Key Stocks

A subset of fish and protected species was identified as "key stocks" to be used to monitor bycatch trends over time. These were defined as those stocks that have high bycatch levels, have special importance to management, and/or for which there are stock status concerns. The intention of this system is that changes in bycatch of key stocks over time will provide an indicator of how well NMFS is meeting the bycatch reduction goals of the ESA, the Marine Mammal Protection Act (MMPA) and the reauthorised Magnuson-Stevens Fishery Conservation and Management Act (MSA). Additionally, key stocks showing increasing levels of bycatch may be identified for increased research and/or bycatch reduction efforts. These key stocks were identified using the classification system shown in Fig. 7.

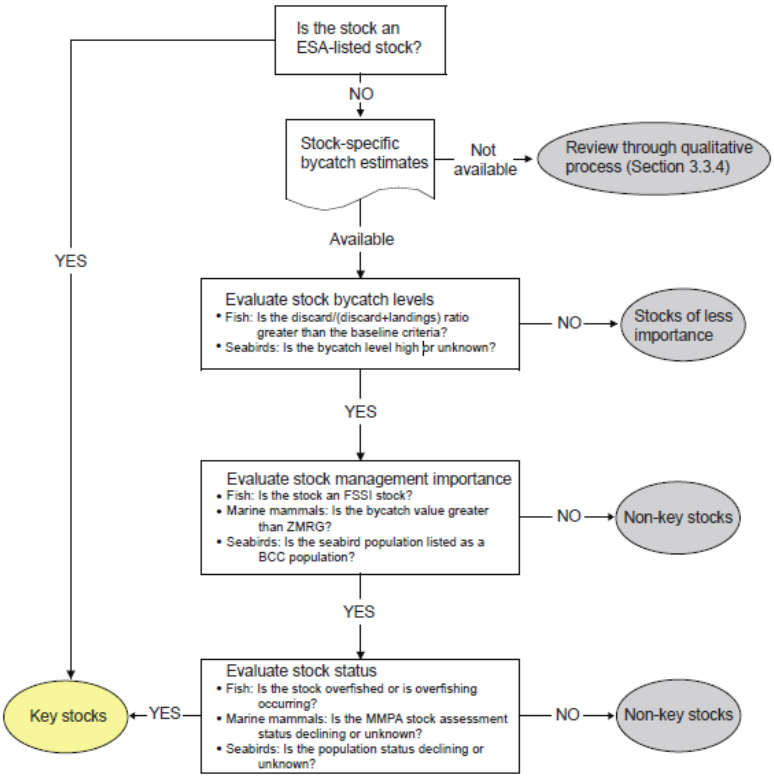

Fig. 7 - Process used to identify key stocks.

All species listed under the Endangered Species Act (ESA) were automatically considered to be key stocks, but non-ESA-listed fish, marine mammals and seabirds were evaluated based on the factors listed above. The process led to a total of 396 fish, marine mammal, seabirds, and sea turtle stocks and populations being classified as key stocks. Stocks occurring in multiple regions were listed as "key" in each region where bycatch was of concern. Of the 269 key fish stocks, 68% are included in the NMFS Fish Stock Sustainability Index (FSSI) (n.b. this index is an important metric used by the US's national status reporting system and was described in a recent report for FRDC - Kennelly, 2014). A further 22% of the key fish stocks are listed under the ESA. Seventy one marine mammal stocks (18% of the total) were identified as key stocks. All sea turtle populations were classified as key stocks because they are listed under the ESA as either endangered or threatened. A total of 30 seabird populations were identified as key stocks.

Fisheries of Focus

In addition to the above performance measures, the report also identifies particular "fisheries of focus". These are fisheries that take one or more of the above key stocks as bycatch, and/or have high total levels of fish bycatch. For each of these fisheries of focus, specific "bycatch estimation improvement plans" were developed.

To identify fisheries of focus, fisheries for which bycatch estimates were available were initially evaluated through a quantitative process to determine the overall fishery bycatch ratio and/or determine whether key stocks were taken as bycatch within the fishery (Figure 8).

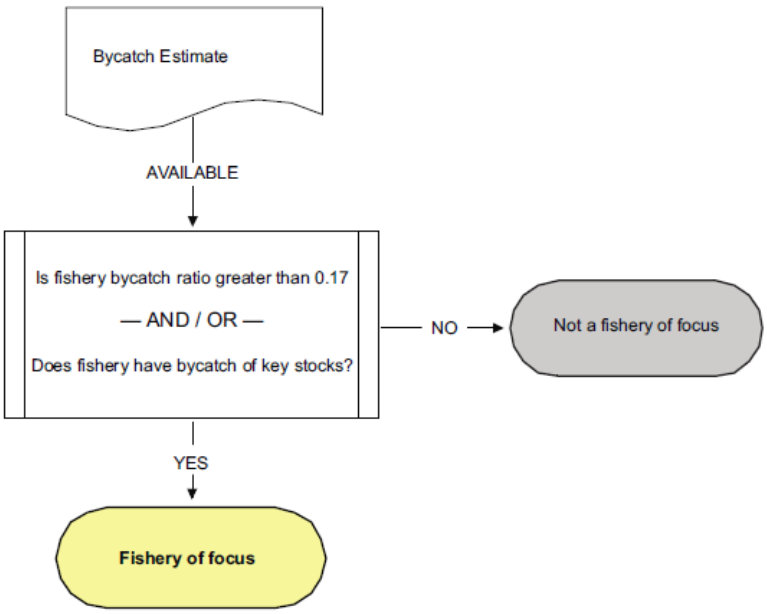

Fig. 8 - Process used to identify fisheries of focus.

The critical cut-off ratio of 0.17 in the above process, above which a fishery becomes a fishery of focus, is the median of the frequency distribution of all fishery bycatch ratios (Figure 9).

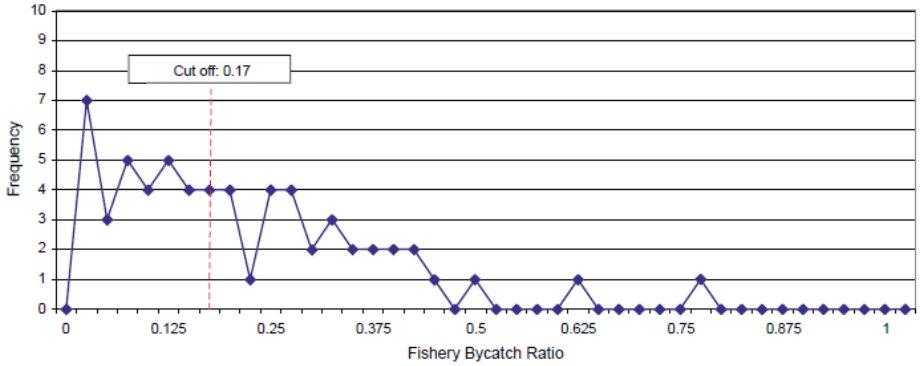

Fig. 9 - Distribution of bycatch ratios, for all fisheries in which fish bycatch estimates were included in the U.S. National Bycatch Report (*n* = 63). The red dotted line indicates the median of the frequency distribution, above which a fishery was designated as a fishery of focus.

Regardless of whether a fishery was identified as a fishery of focus through the above quantitative process, all fisheries included in the report were also qualitatively evaluated against a set of standardised criteria. This second process was important because bycatch estimates were not available for many fisheries and, as such, these fisheries would not have been classified as fisheries of focus under the quantitative scheme. The additional criteria used in this qualitative process were:

- Fisheries with suspected or unknown bycatch which may require pilot observer programs to provide more detailed bycatch information.
- Fisheries where the standard error of the bycatch estimate exceeded the management goal or where uncertainty estimates were not calculated.
- Fisheries using gear with potentially high bycatch (e.g. gillnet fisheries).

All changes based on this qualitative process, and the reasoning behind such changes were summarised in each regional section of the report. This was then reviewed by the National Observer Program and the National Bycatch Steering Committee to ensure consistency across regions.

"**Fishery Bycatch Estimation Improvement Plans**" were developed and provided for all resultant fisheries of focus. These plans provided documentation on each individual fishery, including its current classification tier, relevant management issues, deficiencies in bycatch data collection and estimation, and recommendations for how to improve the latter. To ensure consistency across regions, a standard format was developed and applied to each relevant fishery.

Final comments

The many recommendations in the report provide guidance in setting priorities for maintaining existing bycatch data-collection programs, expanding programs where more

reliable bycatch information is needed, and implementing new programs for fisheries with potential bycatch concerns. The implementation of these recommendations should assist NMFS to increase their baseline knowledge of bycatch levels, help identify fisheries and/or species with potential bycatch concerns, and therefore improve the monitoring of bycatch levels over time.

Future editions of this report are planned to include periodic updates of bycatch estimates for federal fisheries, as well as estimates for state, international, recreational and indigenous fisheries where data are available – eventually making it a truly national reporting system. It is NMFS's intention that, over time, the U.S. National Bycatch Report will provide them, other fisheries management organisations, and the public, with reliable bycatch estimates for all living marine resources, which can be used to more effectively meet NMFS' stewardship mission.

The US Bycatch Report 2013 Update

The first edition of the US National Bycatch Report (summarised above) provided bycatch estimates based on information that was available in 2005. It was the first of a series of scheduled updates intended to document bycatch in US fisheries over time, and to improve consistency in reporting bycatch data.

NMFS determined that, due to the time and resources required to compile the first comprehensive report, it would be updated online in 2013 and 2015 (rather than annually). These updates would include (as appropriate): a short national overview and regional overviews, including progress on addressing recommendations, updated bycatch estimates for fisheries and species covered in the first edition and estimates from newly observed fisheries and species, but exclude fisheries that were no longer observed or species for which estimates were not available.

A schedule of bycatch reporting for the next decade was also included in the first of these updates (completed in 2013 – NMFS, 2013). This schedule involves online updates every 2 years with comprehensive reports every 6 years. Unlike the biennial online updates, the next comprehensive report in 2017 will include the calculation of a national bycatch ratio; regional bycatch ratios; a discussion of the Tier Classification System, Key Stocks and Fisheries of Focus; and a detailed discussion of bycatch estimation improvement plans. The schedule through to 2023 is shown in Table 5.

Table 5 - Timeline for U.S. National Bycatch Reports and updates

Year	Document Type	Data Years Included
2011	Comprehensive Report (first edition)	2005
2013	Online Update (first edition update 1)	2010
2015	Online Update (first edition update 2)	2011-2013
2017	Comprehensive Report (second edition)	2014-2015 + Synthesis of 2010-2015
2019	Online Update (second edition update 1)	2016-2017
2021	Online Update (second edition update 2)	2018-2019
2023	Comprehensive Report (third edition)	2020-2021 + Synthesis of 2016-2021

In 2013 the first online update of the U.S. National Bycatch Report was completed. It includes data for 2010 only (with the exception of some estimates for rare-event species, where data from a range of years were used). The next update in 2015 will include data for 2011 to 2013, which should be more helpful to NMFS in assessing trends in bycatch levels.

NMFS made several improvements in this update compared to the first edition of the report. The first edition included bycatch estimates based on 2005 data, which represented a 6-year lag between the presented data and publication. By using bycatch estimates based on 2010 data in the report, there was only a 3-year lag between the data and publication. NMFS plans to shorten this further to 2 years for the next update, which should be published in

2015, with bycatch estimates based on data from 2011 to 2013. It was noted that shortening the time lag any further would be very challenging due to the time required to collect and analyse the data and then generate bycatch estimates nationwide.

Individual regions also contributed improvements to the update compared to the first edition. For example: the Northeast Region provided fish bycatch estimates for 29 fisheries, compared to 25 fisheries in the first edition; the Alaska Region combined a large number of state fisheries to better reflect management and data collection systems; the Northwest Region provided bycatch estimates for two additional fisheries; the Pacific Islands Region added protected species bycatch estimates for American Samoa; and the Southwest Region contributed fish bycatch information.

Summaries of the data provided in the update are provided in the following tables.

Table 6 - Total estimated fisheries bycatch and landings for each NMFS region. Data are from 2010, and weights are rounded to the nearest pound. N/A = not applicable, i.e. the region did not estimate bycatch in that particular manner. Landings and bycatch in this table do not represent all regional fisheries but rather the fisheries for which the update provided bycatch estimates.

Region	Fish Bycatch (lb)	Fish Bycatch (individuals)	Fish Landings (lb)	Fish Landings (individuals)
Northeast	142,323,456	N/A	860,170,967	N/A
Southeast	230,443,265	4,552,234	133,456,741	N/A
Alaska	203,067,275	N/A	3,285,445,619	N/A
Northwest	22,206,543	1,199,931	481,144,943	148,490
Southwest	N/A	31,671	1,133,895	N/A
Pacific Islands[7]	8,983,027	N/A	23,708,268	N/A
Totals	607,023,566	5,783,836	4,785,060,433	148,490

Table 7 - Total estimated marine mammal, sea turtle, and seabird bycatch by type for each NMFS region. Estimates are for individuals, rounded to the nearest whole animal.

Region	Marine Mammals	Sea Turtles (live and dead releases)	Sea Turtles (mortalities only)[8]	Seabirds
Northeast	2,747	828	0	1,448
Southeast	108	651	6,199	268
Alaska	33	0	0	4,599
Northwest	48	0	0	40
Southwest	338	0	0	59
Pacific Islands	46	80	0	306
Totals	3,320	1,559	6,199	6,720

FAO's 1994 Bycatch Report

Background

The UN FAO first commissioned a global report on bycatch and discards that was published in 1994 by Alverson et al. called "A global assessment of fisheries bycatch and discards" (FAO Fisheries Technical Paper No. 339). Its purpose was to summarise the knowledge at the time concerning the quality and quantity of information on bycatch and discards throughout the world, the biological, ecological, and economic consequences of discarding, the scientific, socio-economic, and political bases of national and international bycatch management strategies, and to evaluate alternative solutions to bycatch problems.

Methodology

The report firstly reviewed the various terminologies used in the scientific literature and established operational definitions for all terms relating to bycatch and discarding. It then built up a database using bycatch and discard data from the available literature and provided provisional estimates of discard ratios by gear type and region. It also provided a global estimate of discards for the world.

Other chapters examined the potential impacts of discards as they related to biological/ecological, economic, and sociological factors, and regional overviews for the Northeast Pacific, Northwest Atlantic, and the Northeast Atlantic. The final chapters examined the evolution of policies and solutions designed to reduce bycatch levels, with a general discussion of the report 's key findings and recommendations.

Data for the report were retrieved from extensive literature searches, augmented by direct contacts with numerous entities to prepare an exhaustive set of references. These sources included individual scientists whose interests in bycatch were reflected in their publications, national fisheries entities, and international fisheries bodies such as IWC, ICES, ICLARM, IATTC, IPHC, FFA, SPC, ICCAT and IFC.

Because weight-based ratio information constituted the only database that had adequate regional and global observations at the time, it was chosen as the basis of Alverson et al's estimates. That is, in short, for most estimates of discards, Alverson et al. assumed that the rate of discard was a function of landings by a given target species.

To address situations where discard data of a species associated with a target species were lacking in a region, the authors applied a set of criteria in order to select surrogate ratio data which were used instead:

- Record must be post-1980
- If a ratio exists for Target Species A in the region in question, use that ratio
- If not, use a ratio for Target Species A from a neighbouring region
- Or apply a ratio for Target Species A derived from a global average of ratios associated with that species
- Or apply a ratio for the species group within which Target Species A resides that is derived from a global average of ratios associated with that species group
- Derive minimum ratios from summary records

- Use minimum-to-maximum range or, when applicable, the global average must include all gear types for which data are available
- Estimates pertaining to the Bering Sea groundfish fishery are derived from comprehensive NMFS observer sampling data for 1992

Using the above criteria, the authors first analysed the discard ratio data (on a weight basis) considering target species in each FAO region (see Fig. 10). Average annual commercial harvests by species and region for the period 1988 through to 1990 were obtained from FAO's landings database, FISHSTAT-PC. These volumes were then applied to the most recent maximum and minimum bycatch ratios recorded in the database for target species in each region. An estimate of discards associated with that target species was then obtained by averaging observed maximum and minimum values for specific fisheries and regions.

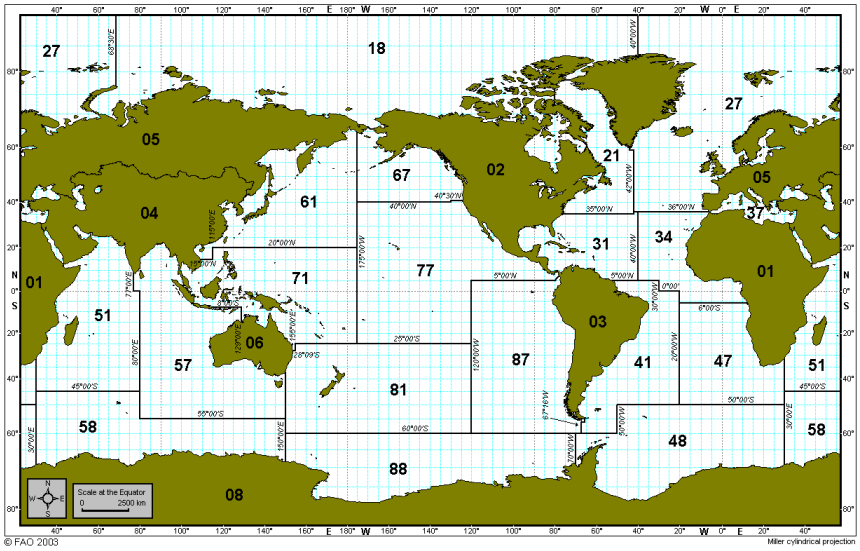

Fig. 10 - FAO's global fisheries regions

Alverson et al. (1994) were very meticulous in describing the many factors that influenced their analyses and estimates and they consistently stated that the estimates provided in the report were, at best, provisional "best guesses". Many potential biases and errors that may have compromised estimates were noted: At times the authors used total reported bycatch estimates and, from these, back-calculated quite subjective estimates of retained species; There were known to be significant errors due to variations in reporting procedures where some entities equated bycatch with total discards, secondary target species and discards, or selected species within the bycatch complex and there was often a failure to define what sector of the bycatch was being reported; Different operational definitions were used by different researchers and countries; biases due to the use of number-based ratios, weight-based ratios, time/area variability and the application of various statistical procedures to species with clustered distribution patterns were also noted to be potential sources of error; In calculating global estimates and in developing summary tables of discard ratios by gear and region, in some instances the authors used their best judgment in the selection of available bycatch data for particular regions or fisheries with which they were especially familiar; And in some cases, assumptions were made about average weights of individuals discarded in order to convert numbers-based ratio data into a weight-based form which could contribute to global estimates.

Results

Despite all the potential errors, biases and assumptions, the above process yielded the first useful estimates of bycatches and discards. It resulted in a yearly mean estimate of 28.7 million mt of bycatch and 27.0 million mt of discards, based on a target catch of 77 million mt. Using minimum and maximum observations, they estimated a global discard range of 17.9 to 39.5 million mt. At the time, these estimates were considered to be quite conservative because: data were not included for many invertebrate fisheries, nor any recreational fisheries or subsistence fisheries, the database for most areas of the world was incomplete, and discard weights were not included for marine mammals, seabirds, and turtles and, for many areas, invertebrates. Table 8 is a key summary table from the report.

Table 8 – Global marine discards* on the basis of the FAO International Standard Statistical Classification of Aquatic Animal and Plants (ISSCAAP) species groups.

ISSCAAP	Mean Discard Weight (mt)	Landed Catch Weight (mt)	Ratio of Discarded Weight to Landed Weight	Ratio of Discarded Weight to Total Weight
Shrimps, prawns	9,511,973	1,827,568	5.20	0.84
Redfishes, basses, congers	3,631,057	5,739,743	0.63	0.39
Herrings, sardines, anchovies	2,789,201	23,792,608	0.12	0.10
Crabs	2,777,848	1,117,061	2.49	0.71
Jacks, mullets, sauries	2,607,748	9,349,055	0.28	0.22
Cods, hakes, haddocks	2,539,068	12,808,658	0.20	0.17
Miscellaneous marine fishes	992,356	9,923,560	0.10	0.09
Flounders, halibuts, soles	946,436	1,257,858	0.75	0.43
Tunas, bonitos, billfishes	739,580	4,177,653	0.18	0.15
Squids, cuttlefishes, octopuses	191,801	2,073,523	0.09	0.08
Lobsters, spiny-rock lobsters	113,216	205,851	0.55	0.35
Mackerels, snooks, cutlassfishes	102,377	3,722,818	0.03	0.03
Salmons, trouts, smelt	38,323	766,462	0.05	0.05
Shads	22,755	227,549	0.10	0.09
Eels	8,359	9,975	0.84	0.46
Total	27,012,099	76,999,942	0.35	0.26

*Includes bycatch landed but unreported by species in industrial fisheries.

Although the major objective of the report was to estimate regional and global levels of bycatch and discards, a considerable portion of the report dealt with northern temperate fisheries due to difficulties in acquiring data from other parts of the world. Thus, there was a paucity of data from many regions, and many observations involved data taken over short time periods from a small fraction of fleets or even single sampling efforts done by research vessels. The authors noted that these and the other data problems mentioned above made it frivolous to attempt to establish hard statistical parameters around regional and gear-type estimates. Rather, the estimates simply constituted “snapshots” based on collages of observations having various degrees of reliability taken over different seasons and years.

Thus, the authors re-iterated that their global and regional discard estimates should only be used as provisional “best guesses” of the potential magnitude of discarding and hoped that these would stimulate researchers to collect and report better data which would lead to more precise estimates. Recent history has shown that this hope by Alverson et al. has indeed been realised with substantial improvements in bycatch estimation having occurred in the past 20 years.

FAO's 2005 Bycatch Report

Background

Soon after the production of Alverson et al's (1994) report, a FAO Technical Consultation was held in Tokyo in 1996 (FAO, 1996) that discussed many of the issues identified in that report which were thought to have contributed to imprecisions in the estimates provided. That consultation concluded that discards may have been overestimated for some regions in the report. It was also found during that meeting that there was strong evidence that discards were declining in many fisheries throughout the world.

A decade after Alverson's report, FAO considered it timely to review the global situation with regard to bycatch and discards by commissioning an update that was completed by Kelleher in 2005.

Methodology

Kelleher (2005) used a different approach to estimate discards than that used by Alverson et al. (1994) by adopting a fishery-by-fishery approach using information from a broad range of fisheries in all continents.

The Alverson et al (1994) assessment was based on the use of the FAO Fishstat database of national catches. This database provides catch information (in practice, the live-weight equivalent of landings) by country, FAO area and species (or species group). Alverson et al.'s estimates of discards assumed that discards were a function of these landings of target species. However, the major flaw with such an approach (as identified by FAO, 1996, Kennelly, 1996 and Kelleher, 2005) is that there is no *a priori* reason why the discarded quantities of a species should bear any relationship to the landings of a target species. In particular, the Tokyo meeting had problems with Alverson et al's "application of questionable discard rates to fisheries for which discard information was missing - particularly between regions - and application of discard rates to some marine fish landings that have catch components taken in other fisheries - mainly tropical shrimp fisheries."

The approach used by Kelleher is based on the premise that discards are a function of the landings of a fishery, rather than a function of the landings of a particular species. Kelleher complied an inventory of the world's fisheries in a database where each record contained quantitative data on: (i) the total landings of the fishery; and (ii) either the total quantity of the discards or the percentage of the total catch that is discarded. The total quantity of discards for a given fishery was usually extrapolated from studies done on a sample of the fishing activities.

The information was compiled from three principal sources: (i) the scientific literature and from published national fisheries reports; (ii) reports and "grey" literature available within FAO or publicly available on the Internet; and (iii) contacts with experts in national fisheries administrations, research institutions or regional fisheries organisations, many of whom provided detailed reports and databases.

As for other bycatch reports, post-harvest waste and discards from recreational fisheries were not included but information on the discard of turtles, seabirds and marine mammals was included. Further, as for other bycatch reports (including the US National Bycatch

Report), Kelleher did not quantify either the unseen mortalities caused by fishing or the survival of discards.

Kelleher's fishery-by-fishery approach encountered several difficulties in data compilation including:

- the sheer scale of the task of compiling a list of the world's fisheries and quantifying the landings of each;
- the absence or inaccessibility of information on discards for many fisheries;
- a lack of published fisheries catch statistics on a fishery-by-fishery basis for many countries;
- the failure of numerous publications to distinguish clearly between bycatch and discards; and
- the narrow focus of some studies on the discards of target or commercial species only.

To facilitate the estimation process, certain assumptions were therefore made:

- in the absence of information to the contrary, artisanal fisheries were assumed to have a discard rate of 1 percent or less than 1 percent of the catch;
- in the absence of information to the contrary, "fishmeal fisheries" were assumed to have a discard rate of 1 percent or less than 1 percent of the catch;
- with some exceptions, Southeast Asian fisheries were considered to have a discard rate of 1 percent of the catch;
- tuna and other highly migratory species, and other fisheries for which statistical information has been collected by regional fisheries bodies, were generally aggregated by ocean; and
- fisheries that, in the opinion of the author, were considered to be substantially similar in terms of fishing grounds, target species, fishing area, socio-economic basis and management regime, were considered to have a similar discard rate.

Results

Over 2 000 records of fisheries were compiled into Kelleher's database of which 1 275 contained quantitative information on either landings or discards. Of these, 788 contained information on both landings and discards for a given fishery. Tables 9 and 10 provide summary information the results.

Table 9 – Estimate of the annual global quantity of discards (tonnes)

Summed landings for which discard information was available[1]	78 448 399
FAO average marine nominal catch for 1992-2001 period (from Fishstat)	83 805 355
Weighted discard rate	8.0%
Total estimated discards (from discard database)	6 824 186
Extrapolated global annual discards for 1992-2001 period	7 290 170

[1] Equivalent to 94 percent of a ten-year (1992-2001) average of Fishstat nominal catch.

Table 10 – Summary of discards by major types of fishery (tonnes)

Fishery	Landings	Discards[1]	Weighted average discard rate *(%)*	Range of discard rates *(%)*
Shrimp trawl	1 126 267	1 865 064	62.3	0-96
Demersal finfish trawl	16 050 978	1 704 107	9.6	0.5-83
Tuna and HMS longline	1 403 591	560 481	28.5	0-40
Midwater (pelagic) trawl	4 133 203	147 126	3.4	0-56
Tuna purse seine	2 673 378	144 152	5.1	0.4-10
Multigear and multispecies	6 023 146	85 436	1.4	n.a.
Mobile trap/pot	240 551	72 472	23.2	0-61
Dredge	165 660	65 373	28.3	9-60
Small pelagics purse seine	3 882 885	48 852	1.2	0-27
Demersal longline	581 560	47 257	7.5	0.5-57
Gillnet (surface/bottom/trammel)[2]	3 350 299	29 004	0.5	0-66
Handline	155 211	3 149	2.0	0-7
Tuna pole and line	818 505	3 121	0.4	0-1
Hand collection	1 134 432	1 671	0.1	0-1
Squid jig	960 432	1 601	0.1	0-1

[1] The sum of the discards presented in this table is less than the global estimate, as a number of discard database records could not be assigned to particular fisheries.

[2] Low estimates in some fisheries (e.g. gillnet) are partly a result of the inclusion of high Chinese catches with low or negligible discard rates.

Based on the set of complete records, the sum of the recorded discards was 6.8 million tonnes with total recorded landings being 78.4 million tonnes. The global weighted discard rate was therefore 8 percent. Applying this rate to a ten-year average of the FAO reported global catch, the total extrapolated discards were estimated to be 7.3 million tonnes.

Because of the different method used by Kelleher to obtain this estimate, it is not directly comparable with the previous mean estimate of 27 million tonnes provided by Alverson et al. (1994). Nevertheless, Kelleher's estimate was less than 50 percent of the lower end of Alverson et als's (17.9 million tonnes). Even allowing for some overestimation in the Alverson assessment and some underestimation in Kelleher's, the comparison strongly suggested a reduction in discards at the global level during the decade between the two studies (the 1994 estimate is based on data from the 1980 to 1992 period while Kelleher used data from the 1992 to 2003 period).

Kelleher concluded that such a reduction could be due to a variety of reasons including: (i) greater utilisation of bycatch species in Asia and elsewhere for aquaculture and human consumption; (ii) adoption of more selective fishing technologies and methods, including Bycatch Reduction Devices; (iii) a decline in the intensity of fishing for some species that had high bycatch rates; (iv) a variety of management actions that: prohibit discarding in some countries, set bycatch quotas, impose time/area closures, establish marine protected areas, and no trawl zones, etc.; and (v) more progressive attitudes by fishery managers, user groups and society towards the need to solve discarding problems.

Of particular interest to Australia are the country-specific discard estimates provided by Kelleher and particularly that for Australia (55.3%) which compares (unfavourably) with that of the US (21.7% - now reduced to 17% in the light of the above-mentioned US National Bycatch Report) and 10.2% of Canada. Intuitively, the estimate for Australia is too high (no doubt due to the limited datasets Kelleher has access to). It would seem quite doubtful that Australia's fisheries discard more than they retain. More likely, our discard ratios should be

similar to that for the US and/or Canada because we use similar fishing techniques. But in the absence of any better overall discard estimate, Australia is, unfortunately currently "stuck" with such an inflated number.

In discussing his results, Kelleher provided a series of points that are worth considering for any future attempts to report on bycatches and discards at a national, regional or global level. Firstly, he noted that discard information has a high inherent level of variability requiring high levels of sampling to give accurate assessments. On-board observer data are considered indispensable for the accurate estimation of discards but relationships between discard rates and other variables (such as landings, target species, trip duration, length of trawl tow, market prices, etc.) tend to be weak. Consequently, accuracy depends on the design of appropriate sampling protocols, ideally using onboard observers – a point well-accepted and applied in the US system for bycatch estimation and reporting.

Kelleher regards his study as an evolving tool rather than a static report. He concludes that global bycatch reporting requires a "decentralised" phase at a national or regional level to: (i) verify or update the information in his database; (ii) give a broader "ownership" to discard information; and (iii) compile discard information from countries and fisheries where information is currently deficient.

ToR 2 - Current and future FAO initiatives in this area

The PI on this project visited FAO headquarters in March 2014 and discussed various initiatives that may be developing at an international level to which Australia may be asked to contribute. Four such initiatives were described by various FAO staff: Global Reporting on Bycatch and Discards; the development of LIFE (Low Impact Fuel Efficient) Fishing Gears; Reporting on the Full Utilisation of Seafood Resources; and the Global Record of Fishing Vessels. Whilst only the first of these is directly relevant to this report, a summary of the latter three is included for information in Annex 1.

Global Reporting on Bycatch and Discards

Historically FAO have only required member states to report on landings information for fisheries – not bycatches – for use in their biennial SOFIA report. However, there are recent recommendations for regular reporting of bycatch and discards in SOFIA 2011 (FAO, 2011a) and FAO (2011b)'s Guidelines on Bycatch Management and Discard Reduction (accepted by CoFI). But these recommendations have not yet been implemented by any nation except the United States (as we've seen), although others (Canada, New Zealand and the EU) have signalled their intentions to do so.

Nevertheless, late last year FAO staff recognised that it was approaching 10 years since the Kelleher (2005) report on global discards and 20 years since the Alverson et al., (1994) report. It was considered prudent to maintain this decadal reporting schedule and therefore timely to begin discussions regarding the next report on global bycatch and discards, particularly with regard to the scope of such a report, its methodology, an appropriate team to do the work and potential funders. The current situation is described below:

This new attempt at a global bycatch report is intended to provide a comprehensive update of Kelleher's (2005) bycatch and discard estimates using a similar methodology – ie. a fishery-based approach using discard ratios by fishery and/or fishing method – rather than the target species ratio approach of Alverson et al. It was noted, however, that, compared to the situation 10 years ago, many more programs exist throughout the world that record and monitor bycatches, including numerous observer programs and other initiatives such as Electronic Monitoring, electronic logbooks, smartphone recording, etc. Further, it has been noted that many countries also have developed quite sophisticated systems for capturing such data than was the case a decade ago. The preparation of a new global report will therefore include much more intensive attempts to capture bycatch and discard estimates from individual countries and regions than the previous two attempts. Extensive travel will occur to places where data has been traditionally difficult to obtain, with regional workshops held to explain, locate and extract data for inclusion into the report. That is, rather than have the report developed via the desktop work of one or a few individuals (as was the case 10 and 20 years ago), data will be obtained via more direct involvement of agencies and targeted individuals. Such an approach will not only ensure more accurate information, but also lead to greater and broader ownership of the findings of the report – as recommended by Kelleher (2005). Numerous contacts that work in the area of bycatch

research and management have been developed by the project team over the past 10 years in regions where, previously, bycatch information was difficult to obtain (Latin America, South East Asia, China, the Middle East and the sub-continent). It is the intention to engage these networks in the project.

For this next report, it is planned to not only include estimates of bycatch and discards in terms of tonnes and/or numbers of species, but also to include estimates of the economic impacts and food security issues due to wasteful discarding, the description of measures that have been successful in reducing discards using examples from around the world, and how better utilisation of bycatches has affected the sustainability of stocks.

The project team for this work currently includes staff from FAO, the PI on this present project and other consultants in Europe. Certain key countries and potential funding agencies have been informally approached. The next steps in the development of this project will be a formal description of its scope, timeline, methodology and deliverables which will be developed into a formal prospectus for consideration by potential funders. This is to occur over the next few months with the first workshop currently scheduled to occur in November 2014.

ToR 3 - Benchmark the current Australian situation on bycatch reporting against the information in ToRs 1 and 2

Benchmarking Australia's bycatch reporting system against the above-described US National Bycatch Report, its recent update and FAO's decadal reports is a relatively simple exercise - because Australia simply does not have any such system and therefore has no "mark" on any such "bench"! That is, there has never been any national attempt to gather and report on fisheries bycatch and discarding in Australia.

The Commonwealth Bycatch Report

The closest Australia has come to provide any sort of synthesis in this area is a recently completed one-off report for one of our eight fisheries jurisdictions by Tuck et al, (2013) entitled "Informing the review of the Commonwealth Policy on Fisheries Bycatch through assessing trends in bycatch of key Commonwealth fisheries" (FRDC 2012/046). The purpose of this report was to inform the review of the Commonwealth Policy on Fisheries Bycatch which required an understanding of the bycatch data that have been collected so far, and whether those data provided an indication of the effectiveness of measures put in place to reduce bycatch. For each of the key Commonwealth fisheries examined, Tuck et al. (2013) documented the data collected, the bycatch management processes that had been implemented and temporal trends in observations of bycatch and bycatch composition. The fisheries considered were the Southern and Eastern Scalefish and Shark Fishery, the Northern Prawn Fishery, Sub-Antarctic Fisheries, the Coral Sea Fishery, the Eastern Tuna and Billfish Fishery and the Small Pelagic Fishery.

The report described a number of measures that had recently been introduced to reduce bycatch and discards from these fisheries including: closures to protect sea lions and Gulper sharks, seabird mitigation measures for longline and trawl fisheries, various seal and turtle bycatch reduction devices, and other gear changes to reduce finfish bycatch. The data indicated that these measures have, to varying degrees, reduced bycatch and/or discards. In some cases, however, the availability of data or its precision were either insufficient to make judgments about the influence of bycatch reduction measures, or it was considered too early to quantify any such influences. The report also notes the difficulties in estimating catches and bycatch rates for rarer species and groups of species when, for economic reasons, observer coverages were set at levels appropriate for the much more populous target species. However, this issue was also found to have been reduced somewhat in recent years with such programs expanding their focus to obtain better estimates of the catch of TEPs and other high risk species.

Because this report attempted to consolidate information for our federally managed commercial fisheries (and ignored state-managed, indigenous and recreational fisheries), it could be said that the report is analogous to the US National Bycatch Report which also did not cover state-managed, international, indigenous or recreational fisheries. However, there are several important distinctions: (i) the US report covered a majority of commercial fisheries in the US (152 of 274), whilst our Commonwealth report only covered a small fraction of Australia's commercial fishing effort; (ii) our Commonwealth report did not attempt to estimate the quality of datasets, identify key fisheries or stocks to follow,

estimate a national discard figure to compare against the current FAO estimate of 55.3%, nor provide any metrics that allows one to track progress (or otherwise) in bycatch management and discard reduction through time; and (iii) our Commonwealth report did not develop any sort of national, ongoing system or schedule of bycatch reporting as was the case for the US system.

Bycatch Reporting by Australia's States and Territories

While the above report was a sound attempt to present information on bycatch for Australia's Commonwealth-managed fisheries, such fisheries only represent fishing by approximately 325 vessels. Australia's 7 state and territory jurisdictions manage thousands of commercial vessels (and millions of recreational anglers) - the bycatch from which was not covered in that report. And these jurisdictions, despite having run a significant number of fisheries observer programs over the past few decades, have never produced a consolidated bycatch report for their fisheries, although Western Australia's annual stock status report includes some regular reporting on certain higher risk bycatch species for each WA bioregion.

How we compare

Like virtually all other fisheries jurisdictions in the world, Australia has never produced a national report on bycatch or discarding for our fisheries. That is, we have never attempted to describe or characterise bycatches from the many commercial and recreational fisheries that are managed by our jurisdictions. However, it is important to note that we are not alone in this – in fact, the US National Bycatch Report and its update are the first consolidated attempts by an individual country to report on bycatches – and even those reports do not consider many state-managed, international, recreational or indigenous fisheries. However, other nations and groups of nations (Canada, New Zealand and the EU) have signalled their intentions to begin to develop their own bycatch reports within the next few years.

The lack of national bycatch reports by countries like Australia is not because such a task is impossible. In Australia, there exist many sources of bycatch data throughout our fisheries, albeit not as extensive as the US's impressive data sources - in 2012 for example, the NMFS and the US fishing industry spent approximately $US69 million to engage 974 observers to gather bycatch data over 83,000 sea days in 47 fisheries.

Australia's observer programs and other projects that have gathered data on bycatches are nowhere near as extensive as that in the US. Nevertheless, significant sources of such data do exist (many having been funded by FRDC over the past 20-30 years) in the form of numerous ongoing and one-off observer programs, logbook reports for various commercial fisheries, fishery dependent surveys and recreational creel studies done by state and federal agencies. What is lacking is any consolidation and synthesis of such information in the form of a nation-wide, repeatable reporting system, by which Australia can (i) identify the current

situation with regard to bycatches and discards; (ii) track through time, using appropriate metrics, our efforts to manage bycatch and reduce discarding; and (iii) contribute to international efforts to report and track bycatch and discarding globally. Of course a corollary to such a system will be the provision of better estimates of our national discarding rates which, as we saw earlier, should be a lot less that the current FAO estimate of 55.3%.

As stated in the Introduction to this report, Australia's public own the bycatch and discards from fishing operations and it is a responsibility of government (who are the stewards of these resources on behalf of that public) to regularly report to those stakeholders on their status and the level of risk to those stocks. It is therefore not surprising that we have seen recent requests to develop such a reporting system by various national agencies and other groups. This report provides a pathway to developing such a reporting system in the next section.

ToR 4 - Recommend a clear pathway towards an appropriate national system

In developing a pathway towards an appropriate national system for bycatch reporting in Australia, it is appropriate to first consider the desired outcome one seeks for such a system but also to use, when appropriate, the numerous lessons learned by NMFS and FAO as they developed and completed their reports. In particular, the approach used by NMFS is relevant because, as the first attempt at such a national bycatch report, it sets a benchmark (by definition) which other countries should ideally emulate or improve upon.

As for the US report, the desired outcome from an Australian bycatch reporting system should be the establishment of an ongoing, fully transparent system by which governments, the public and other stakeholders (including commercial and recreational fishing sectors, environmental NGOs, etc.) can track and assess the progress (or otherwise) in the management of bycatch and discards from our fisheries in a cost effective way.

To develop a system that will deliver such an outcome, a logical set of steps is required that is basically similar to those used in the US approach. Whilst the US report involved dozens of staff, cost many millions of dollars and several years to produce, the size of Australia's fisheries, and the smaller number of bycatch monitoring programs that have been done means that the scale of an attempt at an Australian national equivalent will be much smaller. For Australia, such an attempt could involve the following steps:

- Firstly, to determine where we sit nationally with respect to bycatch and discard data, we should initially identify all available reports/papers/unpublished datasets on bycatches and discards from as many fisheries in Australia as possible;
- Next we should assess these datasets and documents and apply a quality score for each so we can assess their relative value and accuracy. A summary "quality" metric should be applied and be available for comparisons with future reports;
- Analyse the information gathered to calculate summary estimates of bycatches for fisheries, species, jurisdictions and the nation. From this analysis we should identify the positives and negatives in our datasets. That is, using a risk-based approach, we should identify those fisheries and fishing methods where we have adequate information, those for which we do not, and any fisheries/methods which may prove useful as surrogates/indicators for particular types of fisheries/methods.
- Using the lessons learned from the above, develop templates, reporting processes, key methods/fisheries/species/surrogates/indicators/etc. to be used in subsequent repeats, and therefore provide a system of reporting to be used as an adjunct to the current SAFS reporting system.
- Develop an initial first bycatch "report card" for Australia using an appropriate traffic light system based on the above analysis and so compile Australia's First National Bycatch Report.
- Repeat this process periodically as a part of SAFS and as a mechanism to inject data into the Fishery Health Check system currently under development. The US bycatch reporting system involves a schedule of online updates every 2 years with a full report every 6 years, and the FAO process is a decadal one. Australia should probably try to aim for updates every 5 to 10 years – which would allow for

reasonable regularity and also sufficient time for improvements in bycatch management to take effect.

References

Alverson, D.L., M.H. Freeberg, S.A. Murawski and J.G. Pope. (1994). A global assessment of fisheries bycatch and discards. FAO Fisheries Technical Paper No. 339. Rome, FAO. 233 pp.

FAO (1996). Report of the Technical Consultation on Reduction of Wastage in Fisheries. Tokyo, Japan, 28 October - 1 November 1996. Fisheries Report No.547

FAO (2011a). Review of the state of world marine fishery resources, FAO Fisheries and Aquaculture Technical Paper 569, ISBN 978-92-5-107023-9, 334pp.

FAO (2011b) –International Guidelines on Bycatch Management and Reduction of Discards, Food and Agriculture Organisation of the United Nations, Rome 2011. ISBN 978-92-5-006952-4, 73pp.

Flood M, Stobutzki I, Andrews J, Begg G, Fletcher W, Gardner C, Kemp J, Moore A, O'Brien A, Quinn R, Roach J, Rowling K, Sainsbury K, Saunders T, Ward T, Winning M (2012). Status of key Australian fish stocks reports 2012. Fisheries Research and Development Corporation, Canberra, 420pp.

Kelleher, K., (2005). Discards in the world's marine fisheries. An update. FAO Fisheries Technical Paper No. 470. Rome, FAO. 152 pp.

Kennelly, S.J. (1996). Review of FAO Fisheries Technical Paper 339 for the Northwest Atlantic (FAO Region 21). 18pp.

Kennelly, S.J., 2014. Benchmarking Australia's national fisheries status reporting system. Final FRDC Report 2013/233, ISBN 978-0-9924930-0-4, March, 2014. 82pp.

NMFS (2011). U.S. National Bycatch Report. W.A. Karp, L.L. Desfosse, S.G. Brooke, Editors. U.S. Dept. Commerce, NOAA Tech. Memo. NMFS-F/SPO-117E, 508 p.

NMFS (2013). U.S. National Bycatch Report First Edition Update 1. L.R. Benaka, C. Rilling, E.E. Seney H. Winarsoo, Editors. U.S. Dept. Commerce, 57 p.

Tuck G.N., Knuckey, I. and Klaer, N.L. (2013). Informing the review of the Commonwealth Policy on Fisheries Bycatch through assessing trends in bycatch of key Commonwealth fisheries. Fisheries Research and Development Corporation final report 2012/046. 240p.

Annex 1 – Additional FAO initiatives

As agreed with FRDC, while in FAO headquarters, Prof Kennelly also sought out current FAO initiatives to which Australia may be asked to contribute. The following is a summary.

LIFE (Low Impact Fuel Efficient) Fishing Gears

In recent years, staff at FAO and others have recognised that certain developments in fishing technology could be able to simultaneously address two key issues that are characteristic of mobile fishing methods throughout the world: the environmental impact of such gears on benthic habitats and ecosystems, and the very significant (and growing) costs that such methods incur in terms of fuel use. That is, demersal fish and prawn trawlers and mollusc dredgers are known to significantly disturb benthic habitats due to the contact made by otter boards, ground chains, dredges, etc. Such gears also cause significant drag and elevate fuel costs to a point where fuel is usually the single largest ongoing expense for such operations. Reducing benthic impacts through modified fishing gears and practices would therefore greatly reduce environmental damage, the carbon footprint and the costs incurred by such operations.

As a first step in developing such technologies globally, an approach that has been shown to work quite well is to firstly draw significant international attention to the concept via a dedicated symposium/workshop. Researchers, gear technologists and fishers would be invited to present and discuss alternative ways of fishing for species that have traditionally been caught using trawls and other fuel-hungry, habitat-damaging gears. Such methods as trapping shrimp (instead of trawling), low impact trawl boards, ground gears and beam trawls instead of otter trawls, diving versus dredging for scallops, etc. are all examples that have been, and currently are, being tested throughout the world. The goal of the symposium will be to bring such projects together in order to “smoke” out the various pieces of work going on in this field, identify potential best practices, disseminate the information broadly via proceedings, reports and press releases, and so establish an ongoing dialogue and awareness of the concept and its significant potential.

The development of this symposium is currently in its early stages, with a formal proposal to funders being prepared over the next few months.

Reporting on the Full Utilisation of Seafood Resources

A key factor considered when prioritising expenditure and the allocation of resources by national governments, international agencies and funders, involves the scale of the various sectors involved. This is the case, for example, when reports are provided to the UN General Assembly regarding global figures for agriculture production - which include fisheries and aquaculture figures. However, FAO Fisheries staff consider that the current way the world reports on fisheries and aquaculture production (which usually are values at the point of first sale of commercially caught fish) significantly underestimates the world’s fisheries in

terms of both their social and economic value. This is causing a consequential disproportionate reduction in the allocation of resources (and funding) to fisheries matters compared to competing agricultural matters. This issue is growing in importance as food security concerns increase throughout the developing world – particularly in regions where seafood is the major source of protein.

That is, while it is appropriate to quantify the value of agriculture production in terms of the quantity and "farm gate" value of particular products, reporting on the value of fisheries should include the value of ALL the catch caught and consumed, including non-commercially-caught fish by recreational and subsistence fishers, whole-of-chain uses of the catch, social and cultural values associated with the catch, etc. Such data are not only important for a more accurate reflection of the value of fisheries for funding allocations, but are also important for use in resource modelling and management.

As a result of the above, FAO are currently working on a proposal that will ask nations to report on their fisheries landings in a much more holistic way, detailing not just landings but more complete estimates of the value of the entire utilisation of seafood resources, including the whole-of chain use of the seafood, non-commercial catches, social and cultural values of the sector, etc. As a first step, FAO intend to do a scoping study to identify the sorts of data that are available along these lines in various countries (this will probably include Australia) before determining the best way forward to establishing a system for obtaining such information on a regular basis.

The Global Record of Fishing Vessels

The Global Record of Fishing Vessels, Refrigerated Transport Vessels and Supply Vessels is an initiative run by FAO that intends to make vessel-specific information about all fishing vessels available to all potential users of such data. Its aim is to provide a reliable and rapid way to contrast such data with other sources as a tool to prevent, deter and eradicate Illegal, Unreported and Unregulated (IUU) fishing activities. It is also being developed to assist and complement other international instruments such as the Port State Measures Agreement and the Voluntary Guidelines for Flag State Performance.

The Global Record initiative was born out of the recognition that one of the greatest obstacles in eliminating IUU fishing is the lack of access to information on individual fishing vessel identification, ownership and operation. This lack of transparency means there is no ability to trace vessels as they change name, flag, registration, ownership and operators. With a global tool to disseminate such information, companies and vessels acting illegally would find it much more difficult and costly to operate.

The key component of the record is the Unique Vessel Identifier (UVI), which is a reliable and verified identification of each vessel. The UVI will be with the vessel for its entire life, regardless of changes of flag, ownership, name, etc.

It is estimated that there may be approx. 4.3 million fishing vessels in the world, so the establishment and upkeep of the Global Record is a mammoth task. FAO are therefore adopting a 3-phased development and implementation approach that involves:

- Phase 1: All vessels ≥ 100GT or ≥ 24m.
- Phase 2: All vessels < 100GT or < 24m but ≥ 50GT or ≥ 18m.
- Phase 3: All other eligible vessels, notably vessels < 50GT or < 18m but ≥ 10GT or ≥ 12m.

Currently FAO are nearing the completion of Phase 1 of the above program, mostly using data from the Lloyds register of maritime vessels, the International Maritime Organisation's register of vessels greater than 100GT, and records from the EU and various RFMOs. They are seeking funding from various agencies and countries to move forward with the much larger and more difficult Phases 2 and 3 of the program.