NMSP WP - Food Security - Wild Fisheries

a. Abstract

Fisheries are an important element of global food and economic security. Australia's wild fisheries are relatively small by global standards but have an important ecological, social and political footprint. Fisheries are extremely important for regional neighbours. There are considerable interactions within fisheries, and between fisheries and other sectors.

Funding for fisheries assessment research has been stable or declining while the breadth of that research has increased considerably to meet the objectives of ecosystem-based fisheries management. Key priorities include the need for new smart ways of monitoring and data acquisition including NextGen technologies; expansion of performance evaluation metrics; methods for data-poor fisheries assessment including recreational and indigenous sectors; understanding social license and efficient community engagement; 'whole of system' approaches including explicit consideration of social and economic dimensions, and interactions with other non-fishery sectors; and national standards for monitoring, assessment and management.

b. Background

Fisheries research is conducted by all State agencies and the NT, CSIRO, ABARES, AAD, and a number of universities and museums. In addition research is directly carried out by private providers and consultants and industry. The Status of Key Australian Fish Stocks can be found at www.fish.gov.au.

There have been recent structural changes in distribution of capability. There has been a reduction in fisheries research undertaken by some State agencies particularly on the eastern seaboard. Overall, however, the total numbers engaged in fisheries and aquaculture research have remained relatively stable over the last 5 years as there has been a shift to universities and private consultancies in some cases. A positive trend is the increasing collaboration between institutions. In 2013, total FTEs directly engaged in fisheries and aquaculture research was in excess of 550 FTEs (wild commercial fisheries 60%; aquaculture 33%; recreational fishing 6%; and indigenous/customary 1%) (Murphy and Lewis 2014). Total investment in fisheries research was around $65 million in 2012/13 and has been stable, but slightly declining in real terms.

Fisheries research has been undertaken in Australia for over a century. The more traditional aspects of fisheries research, such as that supporting target species management, is considered a mature science. However, even in this context there are on-going improvements and developments in quantitative methods especially with respect to data-poor, recreational and indigenous fisheries. However, social and economic science is much less developed. In the last 10 years or so, international requirements and market forces placed much greater emphasis on the broader ecosystem impacts of fishing, termed ecosystem-based fisheries management (EBFM), which is not a mature science. Climate change means that status quo management is unlikely to lead to a desired future, and research to underpin management is needed (e.g. distributional changes across national and State boundaries and non-stationarity).

Recent research has concentrated on the development of tools that are cost-effective and applicable to a range of situations. A number of tools developed in Australia, including the various Risk Assessment methods (e.g. Fletcher, 2005; Hobday et al 2011) have been included within the Food and Agricultural Organisation's Toolbox for Implementing the Ecosystem Approach to Fisheries (Fletcher & Bianchi, 2014) these are freely downloadable (http://www.fao.org/fishery/eaf-net/ en). Some are also available from the USA NOAA toolbox (e.g. http://nft.nefsc.noaa.gov/PSA.html). This has also seen the development of new observational methods, risk-based approaches, as well as including the economic and social dimensions of fisheries. Modern computing, observational technology and genetic techniques have meant new methods are being developed for ecosystem research. A significant development has been the increasing use of end-to-end ecosystem models in fisheries drawing from the field of complex systems science. The complexity of these models means

that, in most cases, data and process understanding are now the limiting factors. Recently, there has also been increasing interest in integration of economic and social objectives into 'whole of system' approaches.

Australian fisheries research is highly regarded and well cited. For example, CSIRO is rated in the top 0.1% of global research institutes in four research fields of which Marine Biology and Fisheries is one. Six Australian universities had ERA rankings of three or four in the latest ERA report, in the fisheries/marine biology category. In addition, while attempts to rank nations in terms of their ability to successfully implement fisheries (and Ocean) management should be interpreted with extreme care, Australia is consistently ranked very highly. For example, Australian was ranked 40th according to the Ocean Health Index http://www.oceanhealthindex.org/Countries/l (Halpern et al., 2012) (the US was ranked 75th and the United Kingdom 105th), 4th in terms of compliance with the FAO Code of Conduct for Responsible Fisheries (Pitcher et al., 2009), and 7th in terms of overall performance in terms of EBFM (Pitcher et al., 2008). These examples demonstrate the quality of the research that underpins our management.

Major sources of funding are the Commonwealth government (Department of Agriculture, the Australian Fisheries Management Authority), FRDC, State governments, CSIRO, ARC and the industry.

c. Relevance

Fisheries are an important element of global food and economic security. In 2011, wild fisheries and aquaculture produced 155 million tonnes globally, of which wild fisheries contributed 94 million tonnes (83 million tonnes marine) although this has been stable while production from aquaculture continues to rise (FAO 2014). Global fisheries as a food source provide 2.9 billion people with 20% of their protein. They provide employment for 46 million people directly and 180 million including secondary activities. Demand for seafood is likely to increase with increasing populations both domestically and in our region, placing additional pressure on sustainable production of seafood.

The Department of Agriculture estimates that Australia produces enough food to support 60 million people and overall, Australia is fortunate when it comes to food and hence food security is not an acute issue for the nation. However, the world is changing and Australia will face challenges related to climate change, competition for resources, changing economic conditions, regional stability etc. For example, >50% of current Australian agricultural land is threatened by soil acidity, 17% by salinity (Stirzaker 2012), the future median year is projected to match a dry year today with a potential drop in production (e.g. in wheat, sugar, cattle and sheep) of 5-20% or more, which reduces Australia's export capacity (Gunasekera et al 2007). This means fisheries and aquaculture may have a growing role in Australia's food security. In addition, as major producing developing nations utilise their own seafood for domestic use, this will put growing pressure on developed nations, including Australia, to address production requirements.

Australia's commercial fisheries industries are relatively small by world standards, accounting for 0.2% of global marine fisheries landed by tonnage and 2% of landed value (FRDC 2010). The domestic demand is such that imports exceed exports both in tonnage and value (Skirtun et al 213). Australia's relatively small production is also highlighted by its juxtaposition against its Asian neighbours, with Indonesia one of the world's largest fishing nations - ranked 2nd for fisheries production (FAO 2014). The Indonesian annual wild fishery catch is 5.4 million tonnes and more then 2.7 million people rely directly on fishing activities for part or all of their income (FAO 2014). Fish is also a mainstay for food security for Pacific island countries and territories providing 50-90% of animal protein in rural areas and 40-80% animal protein in many urban areas of the Pacific (Bell et al 2009). These fisheries share species and ecosystems with Australia and Australia is bounded by the world's two largest tuna fisheries, in which it has shared interests – politically as well as through access to migrating seafood resources. There is also increasing Australian interest in the Indian Ocean and rim nations in which fisheries are significant industries. Despite the challenges,

Australia's location also presents opportunities for seafood production and export, as well as the provision of services covering the whole fishery management system.

An other element of Australia's fisheries is the catch by the recreational sector. Unlike many other nations in the world, recreational fishing is a major social and economic activity in Australia, with up to four million people participating per annum, and catches of many species exceeding commercial catches (Henry and Lyle 2003). Indigenous fishing is also an important use of our marine resources with growing recognition of the importance of this sector (Calogeras et al 2011).

Across all forms of fishing Australia's fisheries jurisdictions have adopted ecosystem-based fishery management (EBFM) as a policy goal, since the mid-2000s. This is consistent with the growing international demand for environmentally sustainable food production. Australia has well established participatory processes for fishery assessment and management. In general these include direct engagement between resource managers, scientists, the fishery sectors and eNGOs. Our fisheries are considered well managed by global standards. For example, it has been estimated that only 15% of our fisheries are classified as overfished, with an improving trend, compared to 30% globally (FAO 2010, Smith and Webb 2011, Woodhams et al 2011). However, during the recent debate around large factory trawlers fishing for small pelagics (the *Margiris*), it is also clear that there is limited community understanding regarding Australia's fishery management systems and their successes over the last 10-20 years.

Despite the relatively small size of commercial fisheries as an industry (the combined value of fisheries and aquaculture represented <0.2% of Australia's GDP in 2010) they have important ecological, social, and political footprints. The wild fisheries sector is but one user of the aquatic environment. Increasing marine uses can lead to tensions between sectors and generate competing priorities for the same areas. No arrangements currently exist to provide a forum for identifying integrated strategic marine management or for setting spatial management priorities across multiple sectors.

d. Science needs

There remain crucial research needs and challenges. These are in response to community concerns regarding sustainability of commercially harvested species and the broader ecosystem impacts of fishing and interactions between and within fisheries, other sectors and the environment. There are also significant challenges in understanding multiple-use interactions and cumulative impacts. There are clear synergies and opportunities with the other themes, in particular 'Biodiversity conservation and ecosystem health', 'Dealing with climate change' and 'Optimal resource allocation'. New technologies have opened opportunities to provide major research impact.

These science needs can be considered in 5 broad areas, relating to:

Understanding aquatic ecosystems: there are considerable gaps in our understanding of the processes and dynamics of aquatic systems that support fisheries production. Key needs include:

- Improved understanding of the physical drivers of ecosystem dynamics
- Clearer understanding of the dynamic linkages between catchment, coasts and oceans and their role in fishery production
- Understanding the cumulative impacts of multiple use on coastal habitats for fish production
- Limited knowledge of the functional and dynamic relationships between predators and prey, which is a significant gap for operationalising ecosystem models
- The implications of climate change and variability in particular, range shifts, non-stationarity, and ocean acidification (particularly in terms of the jurisdictional challenges and responsibilities this will present as stock production and availability shifts across existing boundaries)

- Research on marine noise, including seismic surveys, on fishery resources and the ecosystem that supports them.

Observations and data acquisition: resources available for fishery monitoring have generally been low in Australia and we have many low value data-poor fisheries. This together with the requirements of EBFM is putting considerable pressure on the need for new smart ways of monitoring and data acquisition. In addition, many of the ecosystem modelling frameworks currently used are seriously data limited. Therefore the key needs include:

- Improved and cost-effective monitoring (e.g. e-monitoring) for data collection and improved assessment strategies for data poor situations
- Implementation of new observational technologies, remote sensing, genetic and biochemical methods
- Improved recreational fisheries monitoring
- A framework for sustained ecological observing including linkages with other observing infrastructure such as IMOS
- Ongoing social and economic data.

Assessment approaches: stock assessment methods for major fisheries are well developed. However, given data and process understanding limitations for many low-value fisheries and EBFM objectives, assessment methods need to be developed that are costs-effective, pragmatic and explicitly account for risk and uncertainty. Research needs include:

- Development of methods to assess Australia's total sustainable fishery production
- Development of harvest strategies that incorporate all sectors – particularly data poor fisheries (includes social and economic indicators where appropriate), as well as influences from beyond fisheries (such as other industries operating in the same area)
- Assessment methods including monitoring and performance evaluation of the objectives of spatial management, including stocks that straddle jurisdictional boundaries
- Common reporting standards for data and assessment methods
- Ecological risk assessment and predictive models
- Identification of cost effective approaches to habitat rehabilitation, stock enhancement and performance measurement
- Qualitative and quantitative assessment models to assist resource allocation that can adaptively incorporate environmental drivers, trophic and habitat interactions as appropriate
- IUU, provenance and traceability.
- **Social and economic considerations**: there has been increasing focus on economic and wider social issues in recent years. Economic reference points are being set for some fisheries; incentives are being considered to mitigate fishery interactions, and there is ongoing debate around sector value. Recent studies have been undertaken to define social objectives and performance measures. Importantly, social license to operate has become a key issue for commercial fisheries. Research needs include:
- Determining overall benefits health/wellbeing of fishing/seafood
- Assessing the economic potential for utilising discards and under-utilised species
- Understanding social license and efficient community engagement – determining preferred uses, measuring performance accordingly and defining acceptable impacts and environmental

standards

- Improved harvesting systems which reduce energy consumption and improve productivity of fishing
- Exploring means to ensure indigenous fishing cultural rights are addressed and process to develop an indigenous catch and allocation model
- Efficacy and implementation of economic instruments (such as offsets)
- Understanding common measures and differences in 'values' for each sector
- Understanding and communicating health and nutrition benefits from fish and fishing
- Understanding market dynamics, trade and market access and how these may need to change moving forward if environmental change or ecosystem based approaches to sustainable management suggest that species targeting needs to shift away form the species that have traditionally defined the Australian palate
- Processing and supply chains for eco-produced and certified seafood products
- Economic evaluation of enhancement strategies
- The ability to manage our fisheries to ensure that the community receives optimal benefit from fisheries resources in the form of either recreation, food, employment or economic rents.

'Whole of system' and multiple-use approaches: fisheries are but one user of aquatic systems and the interaction of them with other industry sectors and biodiversity conservation is facing increasing scrutiny. The recent development of qualitative and quantitative ecosystem modelling frameworks provides the basis to explicitly account for multiple objectives and the objectives of multiple sectors. Such approaches are crucial to identifying the trade-offs between objectives, within and between sectors. There are many challenges to operationalising these approaches (as mentioned above). Perhaps the greatest is how to robustly model the socio-ecological system including human behaviour and institutional dynamics. Research needs include:

- Operationalising end-to end- quantitative ecosystem models
- Assessing the role of spatial management in meeting EBFM and EBM objectives
- Understanding multiple use interactions and cumulative impacts
- Understanding coupled socio-ecological systems, including developing methods to explicitly model human behavior and institutional dynamics
- The tool kit to explicitly identify trade-offs (including cost benefit analysis)
- Mechanisms for tradable rights within and between sectors
- Adaptive ecosystem based management approaches that support resilience, recognise the inherent socio-ecological nature of Australia's marine resources and provide a basis for flexible sustainable multiple management that supports food.

e. Perspective

Food security is an important issue for Australia and our regional neighbours. With a growing population, increasing demand by other users for access to aquatic resources, compounded by long term changes in the environment due to climate change and the increasingly crowded marine and coastal space there are significant challenges to be met. Food security is not only about the volume of product, of which seafood is a major source, but also to maintain human health.

Certainly, in Australia, wild fisheries research is undertaken against a backdrop of stable or declining funding for monitoring, research and assessment of wild fisheries. As a result of Australia's unique

biogeography and oceanography, many Australian species are endemic (E.g. 70% of in the south). In addition the breadth of this research has increased significantly over recent years. Consequently, cost-effective, smart and well prioritised activities are required.

Significant challenges for Australia's wild fisheries include increasing community requirement for government and industry accountability, poor social license to operate for the industry, and maintenance of resource access including the recreational and indigenous sectors whilst still maintaining a viable industry. Current challenges to sustainable management are likely to be compounded by long-term changes in the ocean environment which limit the value of past experience and historical patterns. Regionally challenges include capacity, resources and suitable institutional frameworks.

As identified above marine research has a role in addressing these challenges through advances in ocean observation systems, developing methods to assess data-poor species and fisheries, bio-economic research, 'whole of system' modelling frameworks, and social research into governance systems, including better understanding of human behaviour (Fulton et al 2011).

Australian fisheries scientists are extremely well connected and highly respected internationally through formal and informal mechanisms. Maintenance of these relationships will be extremely important as issues around food security grow.

The Australian Fisheries Management Forum's recent 'National Statement of Intent' identifies 4 goals for fisheries and aquaculture, which are that they:

- are managed, and acknowledged, to be ecologically sustainable
- have secure access to resources
- are profitable and viable
- support the health of habitats upon which they rely.

These have informed the following priorities at least those in the short term. Into the long term it is hard to anticipate what will be the highest priorities. However, if an adaptive approach is maintained then these issues can be addressed as they become apparent rather than being missed by focusing on topics which may decline in importance with time.

Science Priorities: 5-year horizon

- Fishery assessment methods and harvest strategies, particularly for data-poor species and fisheries, standardised and reported across all jurisdictions
- Assessing the efficiency of citizen science
- Improved recreational fishing data sets and incorporation in assessments
- Agreed national science and management standards to support increased efficiency across jurisdictions and improved community confidence
- The role of spatial management (including those for other purposes, such as conservation) in fisheries and develop performance measures
- Methods and approaches to estimate total national sustainable fisheries production
- Research on social license to operate and define activities necessary to support debate around acceptable impacts and environmental standards
- Methods to better integrate coupled socio-economic and biophysical approaches to resource assessment

- Agreeing and managing towards clear targets for our fisheries and explicitly identifying the trade-offs between competing objectives
- Improved methods to mitigate the impacts of fishing on TEPs, discards and habitats including performance metrics
- Addressing barriers to full and effective indigenous involvement in mainstream fisheries decision making processes and develop models to determine indigenous catch and allocation
- Implementation of new observational technologies, remote sensing, genetic and biochemical methods. Improved methods for recreational fisheries monitoring. Develop a framework for sustained ecological observing including linkages with other observing infrastructure such as IMOS
- Fill critical information gaps regarding ecosystem process, such as the way in which relationships between predators and prey may change through space and time; the implications of climate change and variability in particular, range shifts, non-stationarity, and ocean acidification on stocks, ecosystems and management arrangements; and a clearer understanding of the dynamic linkages between catchment, coasts and oceans and their role in fishery production
- Assess the implications of marine noise on fishery resources and the ecosystems that support them
- Cumulative impacts including dredging, marine harvests, coastal development.

Science Priorities: 10-year horizon

- Operationalise end-to end ecosystem models. Development of a tool kit of socio-ecological frameworks that span scales and levels of data availability (as has happened for biophysical assessments) and extend the tool kit to enable trade-offs within and between users of marine resources. Investigate the science basis for acceptable impacts and environmental standards
- Implement a national ecological observing framework that supports research in fisheries, biodiversity conservation and other marine uses
- Integrate citizen science where appropriate in data sets that inform food systems
- Given the likely changes in climatic conditions and other environmental drivers, determine whether there are key habitats within each bioregion that drive fisheries production and, where relevant, develop cost effective methods to monitor changes to these habitats through collection of empirical data
- Investigate increasing productivity through habitat repair, enhancing habitat and stock manipulations and determine the ecosystem and policy implications of such activities
- Explore the remaining potential in wild fisheries production through emergent fisheries and better utilisation of under-utilised species and bycatch etc
- Have an open discussion on acceptable impacts and interventions (as ecosystems shift under global change it needs to be clear whether enhancement, translocation, human-assisted closure of life histories etc are considered acceptable or desired management actions by society).

Science Priorities: 20-year horizon

- Gaps and challenges with respect to impacts of changing climate on fisheries and coastal communities; several neighboring nations predicted to be affected even more intensively than Australia which will put pressure on Australia to assist in seeking solutions and contributing to global food production

- Cumulative impacts and competition for space will grow with expanding marine industries, in addition upstream pressure could have significant effect on marine production, so integrated management is required. The transition to such an approach is likely to be on a generational scale (unless accelerated by changing public opinion or a significant event). Consequently, there will be further work required on how to operationalise and effectively implement integrated management.
- Integration of real time monitoring (potentially of large volumes of data) into assessments and research as sensorisation continues and the number of data streams grows. In combination with this will be understanding the reporting needs/desires of a public that is dealing with a general increase in information−what will they desire in terms of access verses filtering?

f. Realisation

The funding for fisheries research has been stable, or declining in real terms, over recent years. This is despite the broadening focus of fisheries management within an EBFM context and the science necessary to support it. The PISC RD&E Strategy for Fisheries and Aquaculture has provided a mechanism to support better collaboration, coordination and reduction in duplication. The National Research Providers Network (Research Directors, representatives from universities and stakeholder groups) has supported this Strategy, but more needs to be done. An overall decrease in availability of funding requires consolidation of groups but could compromise the capacity to address the demands for evidence-based management advice and maintaining the standard of our management of natural resources. Given the current funding limitations, research capacity could be improved through increased collaboration between fisheries agencies, universities and industry by using the existing infrastructure, expertise and availability of research students at universities to address fisheries research (e.g. funded through ARC Linkage and FRDC projects).

Assessment and management of fishery resources requires a commitment to ongoing monitoring and performance evaluation. However, this should be separated from specific research priorities. This will be crucial as funding becomes tighter.

Key capability requirements include:

- The ongoing need for highly quantitative scientists
- Economists and social scientists with experience in the domain leading to monitoring and research in support of the economic, social and cultural dimensions of fisheries and food security (perception, social licence, engagement, institutional dynamics, governance, changing desires)
- Better communication between and integration of disciplines across the bio-physical and social sciences
- National network of research laboratories, including universities, that could, for example, conduct experimental research on climate change and cumulative impacts on fisheries species
- Role of professional societies, e.g. AMSA and ASFB
- Rollout of NextGen technology in an accessible and efficient form, including molecular approaches such as DNA ‘sniffers’
- Rollout of e-monitoring
- Explicitly building on existing research infrastructure such as IMOS
- Access to vessels such as the Investigator to address national challenges

g. *Optional*: Additional comments

h. List of contributing authors and affiliations

Name	Organisation
Li Xiaoxu	South Australian Research and Development Institute
Steven Clarke	South Australian Research and Development Institute
Allison Turnbull	South Australian Research and Development Institute
Steven Lapidge	South Australian Research and Development Institute
Gavin Begg	South Australian Research and Development Institute
Caleb Gardner	Institute for Marine and Antarctic Studies, UTAS
Stewart Frusher	Institute for Marine and Antarctic Studies, UTAS
Fabio Boschetti	Commonwealth Scientific and Industrial Research Organisation
Nick Hardman-Mountford	Commonwealth Scientific and Industrial Research Organisation
Jim Greenwood	Commonwealth Scientific and Industrial Research Organisation
Dirk Slawinski	Commonwealth Scientific and Industrial Research Organisation
Joanna Strzelecki	Commonwealth Scientific and Industrial Research Organisation
Ming Feng	Commonwealth Scientific and Industrial Research Organisation
Hector Lozano	Commonwealth Scientific and Industrial Research Organisation
Olly Berry	Commonwealth Scientific and Industrial Research Organisation
Cathy Dichmont	Commonwealth Scientific and Industrial Research Organisation
Malcolm Haddon	Commonwealth Scientific and Industrial Research Organisation
Geoff Tuck	Commonwealth Scientific and Industrial Research Organisation
Alistair Hobday	Commonwealth Scientific and Industrial Research Organisation
Beth Fulton	Commonwealth Scientific and Industrial Research Organisation
Chris Calegeros	FRDC Indigenous Reference Group
Peter Rankin	Seafood Industry Victoria
Marcus Sheaves	James Cook University
Ray Murphy	Consultant – RDS Partners Pty Ltd
Les Christidis	Southern Cross University
Steve Kennelly	Consultant – IC Independent Consulting
Miles Parsons	Curtin University of Technology
Stephan Schnierer	Southern Cross University
Michael Lowry	Department of Primary Industries, New South Wales
Gary Jackson	Department of Fisheries, Western Australia
Evan Harvey	Curtin University
Jean-Paul Hobbs	Curtin University
Martin Excel	Austral Fisheries Pty Ltd

i. References

Bell JD, Krone M, Vunisea A, Nash WJ, Keeble G, Demmke A, Pontifex S, Andrefouet S (2009). Planning the use of food fish for food security in the Pacific. *Marine Policy* **33**: 64-76.

Calogeras C, Carne R, and Lui S, Schnierer, S. (2011). Shaping Advice for Indigenous Fishing and Aquaculture RD&E within the National Strategy Including Outcomes from the National Forum, 30-31 March 2011, Cairns. FRDC Project 2010/401, Fisheries Research Development Corporation, Canberra.

FAO (2010). *The State of World Fisheries and Aquaculture 2010*. FAO Fisheries Department, Rome. Fisheries Department, Rome.

FAO (2014). *The State of World Fisheries and Aquaculture Opportunities and Challenges*. FAO Fisheries Department, Rome. Fisheries Department, Rome.

Fletcher, W.J. (2005) Application of Qualitative Risk Assessment Methodology to Prioritise Issues for Fisheries Management. *ICES Journal of Marine Research* 62:1576-1587

Fletcher, W.J. & Bianchi, G. (2014). The FAO-EAF Toolbox: making the Ecosystem Approach accessible to all fisheries. *Ocean and Coastal Management.* 90:20-26.

Fulton EA, Smith ADM, Smith DC, van Putten IE (2011). Human behaviour - the neglected source of uncertainty in fisheries management. *Fish and Fisheries* **12** (1): 2-17.

FRDC (2010). Overview of the Australian Fishing and aquaculture industry: present and future. Ridge Partners (Colquhoun E). FRDC Project 2009/214, Fisheries Research and Development Corporation, Canberra.

Gunasekera D, Kim Y, Tulloh C and Ford M (2007). 'Climate change – impacts on Australian agriculture', *Australian Commodities*, vol.14, no.4, December quarter, pp.657-676.

Halpern BS, Longo C, Hardt D, McLoed KL, Halpern BS, Longo C, Hardy D, McLeod KL, Samhouri JF, Katona SK, Kleisner K, Lester SE, O'Leary J, Ranelletti M, Rosenberg AA, Scarborough C, Selig ER, Best BD, Brumbaugh DR, Chapin FS, Crowder LB, Daly KL, Doney SC, Elfes C, Fogarty MJ, Gaines SD, Jacobsen KI, Karrer LB, Leslie HM, Neeley E, Pauly D, Polasky S, Ris B, St Martin K, Stone GS, Sumaila UR, Zeller D. (2012). An index to assess the health and benefits of the global ocean. *Science* **488**: 615-620.

Henry, GW, and Lyle, JM (2003). *The National Recreational and Indigenous Fishing Survey*. NSW

Fisheries Final Report Series No. 48. for FRDC project 99/158. Australian Government Department of Agriculture, Fisheries and Forestry, Canberra, p. 188
http://eprints.utas.edu.au/2526/1/Henry_Lyle_Nationalsurvey.pdf

Hobday AJ, Smith ADM, Stobutzkib IC, Bulman C, Daley R, Dambacher JM, Deng RA, Dowdney J, Fuller M, Furlani D, Griffiths SP, Johnson D, Kenyon R, Knuckey IA, Ling SD, Pitcher R, Sainsbury KJ, Sporcic M, Smith T, Turnbull C, Walker TI, Wayte SE, Webb H, Williams A, Wise BS, Zhou S (2011). Ecological risk assessment for the effects of fishing. *Fisheries Research* **108**: 372–384

Murphy R and Lewis T (2014). RD&E capability audit and assessment for the Australian fishing and aquaculture industry 2013. RDS Partners. FRDC project 2013/410. Fisheries Research and Development Corporation, Canberra.

Pitcher TJ, Kalikoski D, Pramod G and Short K (2008). Not honouring the code. *Science* **457**: 658-659.

Pitcher TJ, Kalikoski D, Short K, Carkey D and Pramod G (2009). An evaluation of progress in implementing ecosystem-based management of fisheries in 33 countries. *Marine Policy* **33**: 223-232.

Smith ADM and Webb H (2011). Sustainability of Australian fisheries from a global perspective. National Outlook Conference, Canberra March 2011.

Stirzaker R (2012). Feeding Australia in 2050. In M.R. Raupach, A.J. McMichael, J.J. Finnigan, L. Manderson, Brian H. Walker (eds). *Negotiating our future: Living scenarios for Australia to 2050*. Volume 2: Background papers. Australian Academy of Science.

Woodhams J, Stobuski I, Vieira S, Curtotti R and Begg G (2011). Fishery status reports 2010: status of fish stocks and fisheries managed by the Australian Government. ABARES, Canberra.

WSSD (2002). Plan of Implementation of the World Summit on Sustainable Development. New York: UN Department of Economic and Social Affairs, Division of Sustainable Development.