BENCHMARKING SOUTH AFRICA'S FISHERIES (Part 2)- GLOBAL COMPARISONS OF SUSTAINABILITY AND MANAGEMENT SYSTEMS

Prepared for Responsible Fisheries Alliance
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INTRODUCTION

The objective of the study was to benchmark the sustainability of five major South African fisheries against three international fisheries per sector, representing in each case the largest global fishery, an MSC certified fishery and a developing world fishery. The fisheries, as identified by the Responsible Fisheries Alliance, are listed Table 1.

The concept of sustainability in fisheries is complex and on a broader scale encompasses ecological, economic, institutional, social and technological dimensions (FAO 2011a, Preikshot et al. 1998, Pitcher and Preikshot 2001, Garmendia et al. 2010,). For the purpose of this study we define a sustainable fishery simply as one whose practices can be maintained without reducing the ability of the targeted species to maintain its population at healthy levels, and without adversely impacting other species within the ecosystem by removing their food source, accidentally killing them, or damaging their physical environment. This definition is closely aligned with the objectives of the FAO Code of Conduct for Responsible Fisheries (FAO 2011). The definition we use here does not include the economic and social dimensions of sustainability.

On the basis of the definition provided above three indicator categories were chosen with which to score and then rank the fisheries with respect to management and sustainability. These were, (i) the current status of the stock, (ii) ecosystem impacts and mitigation measures and (iii) management efficiency.

To compare the fisheries it was necessary to develop an equitable ranking system that would fit across the chosen spectrum of fisheries. There are several methods that can be used to compare the sustainability of fisheries. On such method is RapFish, a non parametric and multi-disciplinary evaluation tool developed by Pitcher and Preikshot (2001). However, Rapfish requires high quality data, which are often not available and particularly for some of the fisheries that were investigated here. Ultimately, based on a review of various sustainability measures the three measures referred to above where chosen as the basis for the comparisons. These three categories adequately encompass the three key elements of the definition for a sustainable fishery. The development of the scoring system is described in the following section. Information and data with which to score the fisheries was obtained from the primary literature, published material or assessments undertaken by the FAO and various credible institutions such as the Marine Stewardship Council, the Marine Conservation Society, WWF-SASSI, the SAFINA Center and Monterey Bay Aquarium Seafood Watch and the Sustainable Fisheries Partnership. It should be noted that the California market squid fishery is not MSC certified and that it was not possible to compare a small regional fishery like the RSA tuna longline and pole fishery with the global, distant water Japanese large pelagic fishery. In the latter case we compared the RSA fishery with the more geographically defined Japanese coastal and offshore tune longline and pole fishery that is restricted to the western Pacific.

Table 1. The global fisheries against which the South African fisheries were benchmarked.

	Local fisheries	**Largest global fisheries**	**MSC certified fisheries**	**Developing world fisheries**
1	SA Cape Hake	USA Alaska Pollock	New Zealand Hoki	Argentine Hake
2	SA small pelagic	Peruvian Anchovy	Argentine anchovy	Chilean Jack mackerel
3	SA large pelagic	Japanese large pelagic	USA Pole & troll Albacore	Indonesian large pelagic
4	SA rock lobster	Western Australian rock lobster	Baja California rock lobster	Brazilian rock lobster
5	SA squid	Peru Jumbo flying squid	California market squid	Argentine shortfin squid

DEVELOPING A RANKING SYSTEM

Several scoring systems were reviewed to develop the most appropriate scoring system for this study. These included the evaluation systems of the SAFINA Sustainable Seafood Program, Monterey Bay Aquarium Seafood Watch, Sustainable Fisheries Partnership, the WWF-SASSI and the Marine Stewardship Council. The overall goal of these systems is to score and rank fisheries on a scale of sustainability whereupon the species is "ecolabled" as being from a sustainable, not so sustainable or non-sustainable fishery. Collectively these standards and "ecolables" contribute towards creating greater consumer awareness of the fragility of our fish stocks, allows consumers to take informed decisions about eating certain seafood products and to foster responsible fishing practices by industry (Deere 1999).

The SAFINA Centers' Sustainable Seafood Program (previously Blue Ocean Institute) used five major ranking criteria (life history characteristics, abundance, habitat quality and gear impacts, management and bycatch), with which to define/describe the health of fish populations. Depending on the score the particular fish is colour coded to promote consumption of fish from sustainable fisheries. The Monterey Bay Seafood Watch scoring system (MBA 2014) uses four sustainability criteria, viz. the impacts of the fishery on the species (or stock) under assessment, the impacts of the fishery on other species, management effectiveness and impacts on the habitat and ecosystem. Each of these criteria is further subdivided into several sub-criteria or factors as shown in Table 2. The Monterey Bay Aquarium system is very systematic and detailed. The SAFINA Sustainable Seafood Programme and the Monterey Bay Aquarium SeafoodWatch programmes have now merged and use the same evaluation and scoring platform (MBA, 2014).

Table 2. Monterey Bay Seafood Watch evaluation criteria (MBA 2014).

Criterion 1 – Impacts on the species under assessment
Factor 1.1 Inherent Vulnerability
Factor 1.2 Abundance
Factor 1.3 Fishing Mortality
Criterion 2 – Impacts on other species
Factor 2.1 Inherent Vulnerability
Factor 2.2 Abundance
Factor 2.3 Fishing Mortality
Factor 2.4 Modifying Factors: Discards and Bait Use
Criterion 3 – Management effectiveness
Factor 3.1 Harvest Strategy
Factor 3.2 Bycatch Management Strategy
Criterion 4 – Impacts on the habitat and ecosystem
Factor 4.1 Impact of Fishing Gear on the Habitat/Substrate
Factor 4.2 Modifying Factor: Mitigation of Gear Impacts
Factor 4.3 Ecosystem-based Fisheries Management

The Marine Stewardship Council promotes sustainable fishing practices and sets and maintains a suite of standards for sustainable fishing and seafood traceability. The standards developed and used by the MSC (MSC 2014a) were considered to be more applicable, particularly because of the logic of the "three principles" of fisheries sustainability (as defined in Table 3). The "FishSource" Scores of the Sustainable Fisheries Partnership (Cannon, 2007) as well as the WWF –SASSI system (WWF-SASSI , undated) also use variations of the three core principles of the Marine Stewardship Council. The three core principles that a certified fishery must meet are that the stock must be fished in a sustainable manner; the fishery must minimize its impact on the environment and must be managed effectively.

Table 3. The three core principles of the Marine Stewardship Council standard (MSC 2014a).

Principle 1: Sustainable target fish stocks A fishery must be conducted in a manner that does not lead to over-fishing or depletion of the exploited populations and, for those populations that are depleted, the fishery must be conducted in a manner that demonstrably leads to their recovery. **Principle 2: Environmental impact of fishing** Fishing operations should allow for the maintenance of the structure, productivity, function and diversity of the ecosystem (including habitat and associated dependent and ecologically related species) on which the fishery depends. **Principle 3: Effective management** The fishery is subject to an effective management system that respects local, national and international laws and standards and incorporates institutional and operational frameworks that require use of the resource to be responsible and sustainable.

The MSC Fisheries Standard then uses 28 performance indicators that, after comprehensive evaluations, are scored to determine to what degree each of the three principles are met. Clearly it was not possible to apply the comprehensive MSC evaluations and scoring system. Instead a simplified version of the MSC system, which also took into consideration Article 7 (criteria for good fisheries management) of the FAO Code of Conduct for Responsible Fisheries (FAO 1995), was developed to rank and then compare the various fisheries with each other. A suite of common indicators were chosen for each of the three MSC core principles with which to score a fishery (Table 3, 4 and 5). For the scoring exercise we chose six different categories of stock status, eight different ecosystem impact and impact mitigation measures and nine different measures of effective management. The maximum scores for the three core principles were; Stock status = 10, Ecosystem impact and impact mitigation measures = 20 and Effective management = 20. After a fishery had been scored the results were expressed as a percentage per core principle and as a percentage of the overall maximum score of 50 points. This allowed us to rank the fisheries independently according to stock sustainability, ecosystem impact mitigation measures and effective management and also holistically across the core principles.

The quantitative criteria used for the stock status categories A1 to A2 are identical to those proposed by Ye (2011), while categories A5 and A6 are slight variations thereof (see definitions below). Category A3 was used to deal with squid fisheries for which, as a consequence of several life history parameters and inter annual recruitment variably, the more traditional metrics are difficult to estimate. In support of this category the reader is referred to the MSC standard (2014), which states that when recruitment is impaired or MSY levels are not available to pronounce on stock status then other proxy indicators and reference points may be used. Lastly, Category A4 was the only way possible to deal fairly with the mainly multi-species large pelagic fisheries.

A1. Non- fully exploited (Ye 2011)

Stock abundance

- Estimates of current stock size are >60% of the estimated unfished stock size.
- Catch rates (CPUE) are >60% of the initial catch rates
- Survey abundance indices are >60% of the initial value

Spawning potential

- Spawning stock biomass is 40% of the unfished biomass

Catch trend

- Catches increased over time when fishing effort has increased

Size/age composition

- Size/age composition of the catch has been stable and has not shown any changes in comparison with that of the initial stage of the fishery.

A2. Fully exploited (Ye 2011)

Stock abundance

- Estimates of current stock biomass are between 40% and 60% of the estimated unfished stock size.
- Catch rates are between 40% and 60% of the catch rates of the initial fishery stage.
- Survey abundance indices are between 40% and 60% of the initial values.

Spawning potential

- Spawning stock biomass is between 20% and 40% of the unfished biomass.

Catch trends

- Catches have stabilized at or clos eto the peak values in the last 5-20 years although there may be interannual fluctuations.

Size/age composition

- Size/age composition is stable (not excessively affected by recruitment, enough age or size classes in the exploited population given the species' life history.

A3. Stock status unknown but resource managed on a sustainable basis

Sustainability indicators

- Catches can be highly variable on inter annual basis but long term trend is likely to be steady.
- Size/age composition is likely to be stable.

A5. Over exploited (with increasing trends)

Stock abundance

- Estimates of current stock size are <40% of the estimated unfished stock size but biomass over last 5 years is increasing
- Catch rates are <40% of initial values but improving 5 year average
- Survey abundance indices are <40% of initial values but 5 years trend shows increasing abundance

Spawning potential

- Spawning stock biomass is <20% of the unfished stocks but average over 5 year period has shown increasing trend

Catch trend

- Current catch is <50% of the maximum but shows increasing trend after a 5 year smoothing.

Size/age composition

- Size/age composition is still unstable (excessively affected by recruitment, too few size classes in the exploited population given the species' life history).
- Trends in size/age composition are evident that indicate decreasing fishing mortality.

A6. Over exploited (with decreasing trends)

Stock abundance

- Estimates of current stock size are <40% of the estimated unfished stock size and biomass shows decreasing trend over last 5 years
- Catch rates are <40% of initial values with decreasing 5 year annual average
- Survey abundance indices are <40% of initial values and 5 year trend shows decreasing abundance

Spawning potential

- Spawning stock biomass is <20% of the unfished stocks and average over 5 year period has shown further decreasing trend

Catch trend

- Current catch is <50% of the maximum and decreasing trend after a 5 year smoothing.

Size/age composition

- Size/age composition is unstable (excessively affected by recruitment, too few size classes in the exploited population given the species' life history).
- Trends in size/age composition are evident that indicate increasing (and/or excessive) fishing mortality.

Table 3. Allocation of points for the six stock status indicators.

A	Stock status MAX	10
A1	Non-fully exploited (B>60% of pristine,CPUE>60% of initial rate,SSB>40% of unfished B)	10
A2	Fully exploited (B=40-60% of pristine, CPUE = 40-60% of initial rate, SSB=20-40% of initial)	8
A3	Stock status unknown but resource managed on a sustainable basis	7
A4	Multi species fishery with under, fully and over exploited stocks	6
A5	Over exploited (B<40% of pristine, SSB<20% of unfished B, but showing signs of recovery)	4
A6	Over exploited (same as above but B, SSB, CPUE and size composition trends decreasing)	1

Table 2. Allocation of points for the eight ecosystem impact and mitigation indicators.

B	Ecosystem impact mitigation MAX	20
B1a	Low habitat impact	3
B1b	Medium habitat impact	2
B1c	High habitat impact	1
B2a	Habitat impact mitigation measures implemented or not required	2
B2b	No habitat impact mitigation measures implemented	1
B3a	Bycatch <5% of catch	3
B3b	Bycatch <10% of catch	2
B3c	Bycatch >10% of catch	1
B4b	Impact on ETP species understood / studied and mitigation measures implemented	2
B4c	Impact on ETP species not well understood and no mitigation measures implemented	0
B5a	Voluntary habitat/ecosystem impact mitigation measures implemented	3
B5b	No voluntary habitat/ecosystem impact mitigation measures implemented	1
B6a	By catch management plan in place	2
B6b	No by catch management plan	0
B7a	Fish bycatch mitigation measures implemented	2
B7b	No fish bycatch mitigation measures implemented	0
B8a	Fish bycatch mainly retained	3
B8b	Fish bycatch partially retained/discarded	2
B8c	Fish bycatch mainly discarded	1

Table 3. Allocation of points for the nine effective management indicators.

C	Effective Management MAX	20
C1a	Regular (annual or biennial) assessments of B, SSB and F or other	3
C1b	Irregular assessments B, SSB and F or other	2
C1c	No assessments	0
C2a	Science based management plan in place in accordance with the precautionary principle	2
C2b	Major differences between scientific advice and management plans	0
C3a	Ecosystems approach to management applied or actively researched	2
C3b	Ecosystems approach to management neither applied nor researched	0
C4a	Best management methods employed (TAC,TAE,ITQs, Closed seasons / areas)	2
C4b	Non optimal management measures employed	1
C5a	Industry actively involved in the management of the resource	2
C5b	Industry not actively involved in the management of the resource	0
C6a	Fishers compliant (Catch vs TAC, over or under reporting of catches)	2
C6b	Fishers not very compliant	1
C7a	Strong MCS measures employed	2
C7b	Weak MCS measures employed	1
C7c	No MCS measures employed	0
C8a	Sea based observer programme in force (ALL Vessels Full Time)	3
C8b	Sea based observer programme in force (SOME Vessels Full Time	2
C8c	Sea based observer programme in force (SOME Vessels Occasionally)	1
C8d	No sea based observer programme	0
C9a	Landbased inspection programme in force (ALL landings)	2
C9b	Landbased inspection programme in force (SOME landings)	1
C9c	No landbased inspection programme in force	0

The allocation of points for each indicator was determined by the number of indicators per criterion. For example for B1 a-c, there are three habitat impact indicators, viz, low, medium and high and hence were scored as 3 for low habitat impact, 2 for medium impact and 1 for high habitat impact. Where a criterion has several indicators that could be scored for each of the fisheries then the highest score would be equal to the number of indicators and the lowest score would be 1. However, where a particular indicator was absent in a fishery then the lowest score would be zero (e.g. C7c = No MCS measures employed).

There are, of course, many more criteria and indicators that could have been used to score the fisheries for each of the three core principles. However, the list was reduced such that they were applicable across the entire spectrum of fisheries that were being assessed. We are of the opinion that the system is adequately robust to allow us to rank the fisheries within a group and across groups.

Most of the ecosystem impact and impact mitigation indicators as well as the effective management criteria are self- explanatory. However there are some for which some additional explanations are provided;

- Industry compliance or non-compliance is scored on the strength of comparing actual catches with recommended TACs for last 5 years or other harvest control rules and or whether there is any under or over reporting.

- The term bycatch as used in this study refers to the catch of non-target species prior to any sorting of the catch. Retained bycatch or discarded bycatch therefore refers to non-target species.
- Presence or absence of a land based inspection programme is scored on the basis of whether or not landings and effort are monitored at the landing sites/harbours and whether relevant information and data are collected to support harvest control rules.
- The indicator "Application of ecosystems approach to management" is scored on the basis of whether or not secondary or tertiary species in the catch are incorporated into the science based management plan and whether or not the stock of the primary species is considered in relation to its role in the ecosystem (eg. as a fodder species in the food web).
- ETP (endangered, threatened or protected) species are defined according to the MSC (2014a).
- Application of co-management measures is scored on the basis of whether or not the scientific management plan that is being implemented to ensure the sustainable future of the fishery has been developed in a participatory manner and ultimately agreed upon by the managing authority or agent and representatives of the fishery and that decision making processes are responsive to issues raised by the industry or the responsible authority and that all deliberations and dealings are transparent and, where necessary, the precautionary principle is invoked.
- The strength or weakness of MCS (monitoring, control and surveillance) measures are scored on the basis of whether or not the management authority / authorities have an operational MSC system and also based on the reported efficacy of the system, vessel requirements for VMS. In addition, strong MCS also implies that there is sufficient evidence to suggest that sanctions are applied. Onboard and land based observers can also be considered under MCS but in this study both are recognized as a standalone criteria and scored separately.

It should be noted that the MSC criteria and their interpretation by evaluators is not beyond reproach. Recently the MSC label has come under considerable pressure on the accusation that the MSC's principles for sustainable fishing are too lenient and discretionary, and allow for overly generous interpretation by third-party certifiers and adjudicators, which means that the MSC label may be misleading both consumers and conservation funders (Christian et al. 2013). Two fisheries that form part of this investigation where fingered in the Christian et al. (2013) study, viz the New Zealand hoki fishery and the Alaska Pollock fishery. The specific objections against the certification of the two fisheries were noted and considered in the scoring exercise.

RESULTS

1. The offshore gadiform trawl fisheries

The four deep sea trawling fisheries examined here where the South African hake fishery, the USA Alaskan pollock fishery, the New Zealand hoki fishery and the Argentinian hake fishery. The comparative scores of the four fisheries are shown in Figure 1 and the scores per assessment criterion are shown in Table 4 and Table 5 summarises all indicator scores.

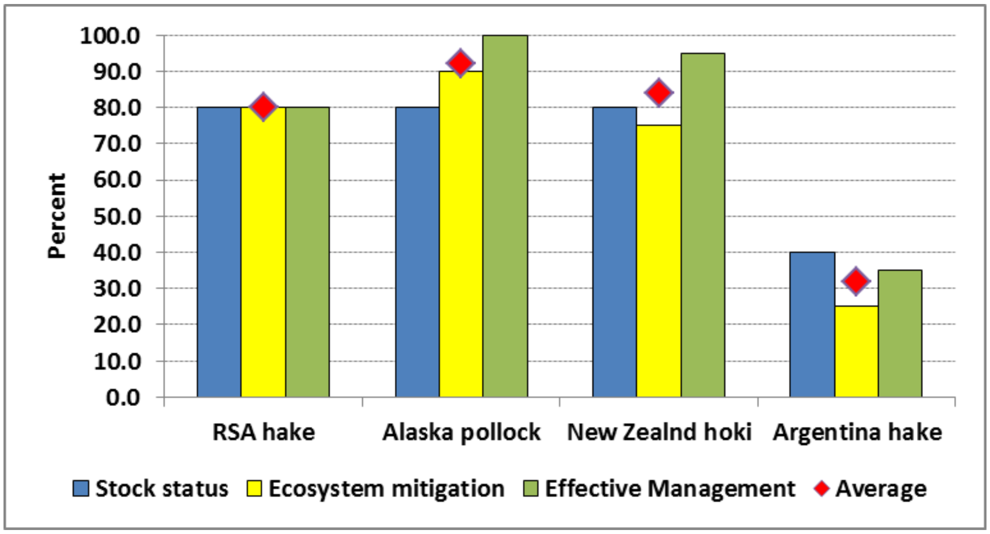

Figure 1. Benchmark criteria and average percent score for the four offhsore gadiform trawl fisheries.

Table 4. Benchmark scores for the four offshore gadiform trawl fisheries, MSC certification and ranking.

POINTS	RSA Hake	USA Alaska Pollock	New Zealand Hoki	Argentina Hake
Stock status (10)	8	8	8	4
Ecosystem mitigation (20)	16	18	15	5
Effective Management (20)	16	20	19	7
Total score (50)	40	46	42	16
Average	13.3	15.3	14.0	5.3
MSC certified	Yes	Yes	Yes	No
Ranking on average score	3	1	2	4

The hake fishery in South Africa contributes more than half of the value of all fisheries nationally. The main export markets are Europe, Australia and the US. The offshore trawl fishery targets deepwater hake, *Merluccius paradoxus*, on the shelf edge from the Namibian border southwards. The shallow water hake, *M. capensis*, is the target of the inshore trawl fishery, which operates mostly on the Agulhas Bank off the south coast. The South African hake fishery was re-certified for a third successive time in 2015 (SADSTIA 2015, Andrews et al. 2015).

The fishery is managed by way of an OMP, which is philosophically different from the usual stock assessment procedures, in which the assessors choose a “base case” that reflects some perception of median or mean tendency of the status of the stock. The OMP process avoids this by focusing on a large set of possible biological scenarios (a “reference case”) without assigning them some arbitrary probability. The OMP evaluation objectives are to develop the management actions which most robustly address the uncertainties identified in the reference set and in further robustness tests (Andrews et al. 2015).

The “Reference Case” assessment of the RSA hake resource was updated in 2013, using the same methodology as that used in developing the existing OMP (Rademeyer and Butterworth 2010), but with revised and updated data sets. Compared with the 2012 assessment (Rademeyer, 2012), the 2013 assessment included new commercial data (catches, length distribution and CPUE), but no new survey data were available. The main change was the inclusion of new long-line catch-at-length data subsequent to 2000. Details of the methodology are provided in Appendix B of Rademeyer and Butterworth (2013) and a detailed description of the current status of the stock is provided by Rademeyer and Butterworth (2014) and Andrews et al. (2015). The assessment estimates that current *M. paradoxus* female SSB is about 21% of the initial (unexploited) SSB (B0) and about 98% of the SSB at MSY. The current estimate of MSY for *M.paradoxus* is about 111,000 tonnes. For *M. capensis* the assessment estimates that current female SSB is about 68% of B0 and 3.17 times the SSB at MSY and the current estimate of MSY is about 62,000tonnes.

Hoki is New Zealand’s most abundant commercial species and the majority of product from the fishery is exported to the United States, Europe, Japan and Australia (MOF, 2013). The NZ hoki fishery is extensively researched and managed using individual transferable quotas (ITQs) within an integrated management structure between industry and government and by way of management areas in which trawling is not permitted. An Environmental Risk Assessment has now also been completed and is being implemented as part of the fishery’s conditions for certification by the MSC (MSC 2009a).

New Zealand’s hoki fisheries were certified under the Marine Stewardship Council’s programme in 2001 and re-certified in 2007. The Ministry of Fisheries and hoki quota owners contract a range of research programmes to routinely monitor the fishery and undertake annual stock assessments on both stocks. The stock assessment process is open to all stakeholders. These science programmes are actively supported by hoki quota owners through the Deepwater Group (DWG) Limited, a non-profit company established to represent quota owners’ interests in fisheries science and management. DWG represents the interests of hoki quota owners who own 95% of the Total Allowable Commercial Catch (TACC).The hoki fishery consists of an eastern stock and a western stock. Scientific research and assessments are carried out annually on each stock and catches from each are managed within separate catch limits under an overall Total Allowable Commercial Catch (TACC). Separate catch limits are applied as part of the overall catch limit and this is set annually by the Minister of Fisheries and Aquaculture (MOF, 2013). Current SSB levels for the western and the eastern stocks are at 56% and 50% of B_0, respectively, hence biomass levels are currently above the levels to produce MSY. The hoki Management Strategy Evaluation (MSE), upon which the current harvest strategy for hoki is determined, is based on the average annual recruitment levels since 1995. This includes the period of low recruitment but excludes periods of high recruitment during earlier years. For this reason, industry accepts the 150,000 t (+/- 20,000 t) optimum TACC as a conservative level and one that has provision for similar low recruitment potentialities (Deepwater Group Ltd 2013). Hoki have the most comprehensive monitoring and research programme of any New Zealand species with two to four wide-area trawl or acoustic surveys undertaken each year, as well as extensive observer sampling programmes and biological analyses.

The Alaskan Pollock fishery was certified under the Marine Stewardship Council's programme in 2005 and re-certified in 2010 (APA, 2011, NOAA FishWatch 2014, MSC 2009b). The fishery is the largest U.S. fishery and one of the largest food fisheries in the world, averaging over a 1 million tonnes per year. The fishery is also one of the most valuable in the world, the 2012 pollock catch from the Bering Sea was valued at more than $343 million (NOAA FishWatch 2014). Most of the Alaska pollock fishing in U.S. waters occurs in the Bering Sea, although there is also a smaller fishery in the Gulf of Alaska. In recent years, the pollock fishery has accounted for about 30 percent of all U.S. seafood landings by weight. The annual stock assessment process for Alaskan pollock is one of the most robust in the world. One of the longest time series of data on fish abundance and distribution has been collected , and continues to be collected. Annual stock assessment modelling takes into account more factors, including potential ecological impacts, than in most fisheries. The fishery is managed by NOAA through the advice received from the North Pacific Fishery Management Council. NOAA Fisheries uses the advice to develop regulations and provides in-season management measures that control the fishery and ensures that catches are below all of the imposed limits.

While all three fisheries are MSC certified there are some noticeable differences in the allocated scores. The effective management score for the Alaskan pollock and the New Zealand hoki fisheries is higher than for the South African fishery (Table 1). The higher scores are a consequence mainly of the superior MCS measuresand (including the higher frequency of observer presence) applied in the Alaskan and New Zealand fisheries. The Alaskan Comprehensive Federal Fishery Observer Program is the most comprehensive fishery observer programme in the world. All pollock vessels (including processor ships) have two federal fishery observers onboard to monitor and record catches. Observers are also assigned to all onshore processing facilities and are trained (and certified) by the NMFS to report data electronically as it is collected. Through a unique industry-initiated program called SeaState, fishers know exactly how much of the quota is remaining at any given time (APA, 2011). In NZ the landings inspection programme covers 100% of all landings (Deep Water Group 2013). Prior to 2012 all South African offshore fisheries, including the hake trawl, hake longline, large pelagic, small pelagic, south coast rock lobster and the west coast rock lobster fishery had a formal observer programme. The government sponsored observer programme was terminated at end of 2011, through administrative inefficiencies. It is anticipated that the DAFF will issue a tender for the revival of the formal observer programme in 2015. However, recognizing the importance of the observer programme the SADSTIA funded a very efficient observer programme for the inshore and the offshore hake industry and there is a limited industry sponsored hake longline observer project. The level of observer coverage under the SADSTIA programme is reported to be higher than that previously achieved under the government programme. When it was active the government observer programme covered between 5 and 10% of all trawling sea days (D. Japp, Capfish. pers. comm., April 2015). The number of vessels operating in the SA trawl fishery is limited by rights allocation and there is little prospect of the number of vessels in the trawl fleet increasing. A sea-day limit is also imposed on all trawlers. This is calculated for each vessel on the basis of its fishing capacity and its quota allocation. The sea-day limit is intended to prevent the use of excess fishing effort to catch non-target species if the hake quota is fully utilized (Andrews et al. 2015).

Both the Alaskan Pollock and the NZ hoki fishery have a lower impact on the habitat than the South African fishery. This is because the Pollock fishery is a midwater trawl fishery (MSC 2009a) and Federal

Regulations prohibit “bottom trawling” for pollock in the Bering Sea and fishery managers have closed pollock fishing in large areas, to minimize competition between fishing vessels and marine mammals that might prey on pollock. The NZ hoki fishery uses mid-water trawling gear during the winter spawning season and bottom trawling gear for the rest of the year (Deep Water Group 2013). The South African hake fishery uses only bottom trawling gear, which does have significant impacts on benthic habitats (Sink et al. 2012). However, it should be noted that the South African industry has voluntarily implemented its own habitat mitigation measure by ‘ring-fencing’ several trawling grounds to reduce the amount of habitat affected (Sink et al. 2012, Smith and Japp 2013). Other voluntary management measures implemented to maintain the long-term sustainability of the hake resources by the SADSTIA include the implementation of an industry supported, though limited, on-board scientific observer program, introduction and setting of Precautionary Catch Limits (PCL) and seasonally closed areas for bycatch species (To prevent the escalation of fishing effort directed at the high valued monk and kingklip, precautionary catch limits were introduced. Industry internally regulates the precautionary catch limits between offshore hake rights holders based on historical performance (Smith et al. 2013). Another voluntary measure implemented by the industry is “ring-fencing”, which limit the trawl footprint to historically exploited fishing areas (Sink et al., 2012), Smith and Japp 2013).

Bycatch and ETP impact mitigation measures are equally well addressed in the three fisheries (Abraham and Thompson 2012, Thompson et al. 2013, Deep Water Group 2013, Hutchings et al. 2009, Maree et al. 2014). The Alaskan pollock fishery is considered one of the “cleanest” fisheries in the world in terms of bycatch at between 1 and 2 % of total catch. However, bycatch of Pacific salmon in the pollock fishery is of concern due to its importance as a commercial and subsistence species. The study by Christian et al. (2013) highlights the objections against MSC certification of the Pollock fishery on the ground sof the significant Pacific salmon bycatch. However, since then salmon excluder devices have been tested to reduce the incidental catch of salmon (NOAA FishWatch 2014). About half of the non-targeted species are processed and utilized (GAP, 2011). Some fish, such as salmon, are considered “prohibited species” and are required to be discarded or donated to hunger relief programmes. In June 2011, the North Pacific Fishery Management Council established the first-ever limit on Chinook salmon bycatch in the Gulf of Alaska pollock fishery (AMCC, 2012).

The NZ hoki fishery has a bycatch rate of around 15% (Dep Water Group 2012) and this was the basis of the objection against MSC certification (Christian et al. 2013). Ten percent of the bycatch species are managed under the NZ Quota Management System, while the remainder comprises non quota species (Deep Water Group Limited 2012). However, the high bycatch continues to be a problem in the fishery and includes quota species such as hake, ling and silver warehou. Other bycatch species include the vulnerable deep water sharks such as shovelnose dogfish, seal shark and Baxter’s dogfish and seabird mortalities are considerable (Forest & Bird, 2012). Through various mitigating measures, warp mortalities of large brids such as albatrosses have reduced significantly. However, reducing net captures of small diving birds is proving to be more challenging.

Bycatch in the SA hake fishery has been variably reported to be between 1% to 27% for the inshore and the offshore fisheries (Andrews et al., 2015, Walmsley et al. 2007, Smith et al. 2013). Bycatch in the inshore fishery is higher than for the offshore component of the fishery and bycatch discarding has been estimated at between 1 and 5.4% (Andrews et al., 2015, Smith et al. 2013). Seabird mortality in the fishery has fallen from 18 000 birds per year (Watkins et al. 2008) to approximately 990 seabirds per year (Maree et al, 2014) through the introduction of tori lines (lines with streamers to discourage birds whilst hauling the trawl) and offal discard management (MSC fact sheet, 2013). Most vessels within the sector have on-board Bird Mitigation Plans and undergo routine monitoring and evaluation (Rose, 2011).

AS mentioned above, these efforts have resulted in substantial declines in seabird mortality. On wetfish vessels in the sector, a reduction in seabird mortalities of approximately 90% was reported, with a 99% reduction for albatrosses specifically (Maree et al., 2014).

Moreover, a deep-sea bycatch management plan has been develop for the SA hake fishery, which includes precautionary upper catch limits (PUCL)for the most important bycatch species such as kingklip, monkfish, horse mackerel and silver kob and seasonally closed areas to reduce the bycatch of monkfish and kingklip. A PUCL is now also being considered for panga. In addition the industry has voluntarily designated certain fisheries management areas. These FMA are closed to trawling to protect non target species and benthic habitats. Investigations are underway in the inshore trawl fishery to develop and implement a bycatch co-management programme, which will bring the most significant species landed in this fishery under management. However, discards are not well quantified and monitored (Smith 2013). Moreover, the Marine Living Resources Act, which governs fisheries in South Africa, prohibits the discard of species for, the which there are TACs, total applied effort and precautionary maximum catch limits. There are no additional prohibitions on discarding in the permit conditions (DAFF, 2014). Thus, in the deep-sea sector, there are limitations on discarding five species: two hake species (shallow and deep-water), kingklip, monkfish, and horse mackerel.

Compliance in the three MSC certified fisheries is good and catch levels are very well aligned with the Total Allowable Catch or the Acceptable Biological Catch (see Figures 2,3 and 4).

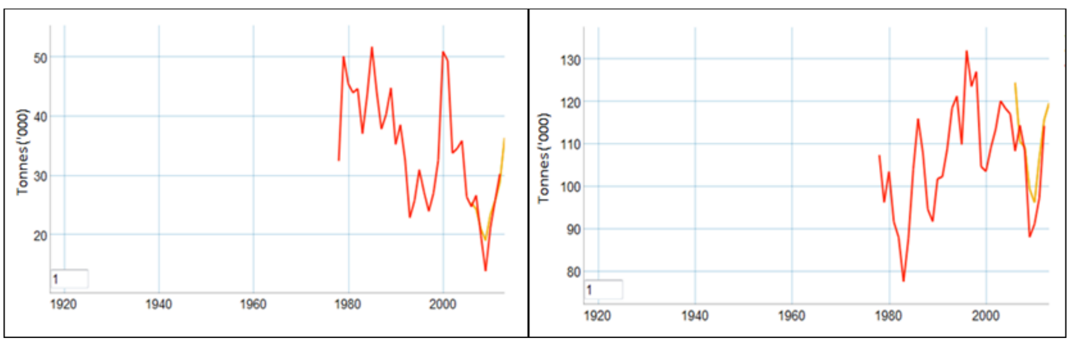

Figure 2. Catches (red line) and TAC (orange line) of shallow water hake (left) and deep-water hake (right). (source: Sustainable Fisheries Partnership).

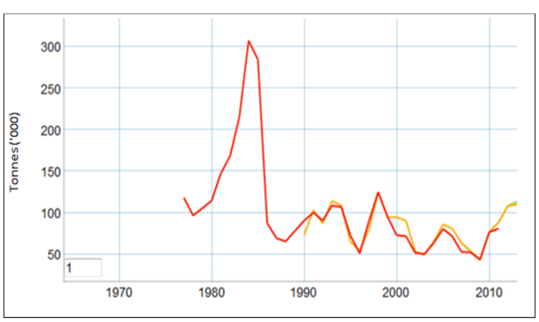

Figure 3. Catches (red line) and ABC (orange line) of US Alaska pollock. (source: Sustainable Fisheries Partnership).

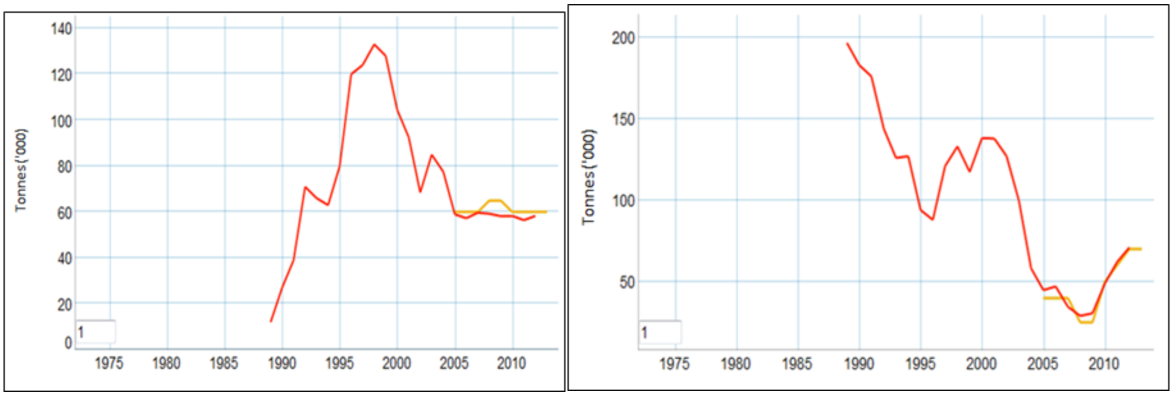

Figure 4. Catches (red line) and TAC (orange line) for the New Zealand Hoki Fishery eastern (left) and western stock (right). (source: Sustainable Fisheries Partnership)

Surveillance in the pollock and hoki fisheries by fisheries patrol vessels is well structured (NOAA FishWatch 2014, MCS 2009a&b). Surveillance in the South African hake fishery is rather dysfunctional at present. Fortunately, South Africa has observer records for over 19 years, dating back to 1995 and sponsored variably by Government and industry or both (Andrews et al. 2015). It is anticipated that a new South African Observer Programme will be launched in 2015 (D. Japp. Capfish. pers. comm. April 2015). Observer data from the SA hake fishery have been the subject of intensive studies by Walmsley et al. (2007) and Daneel and Attwood (2013). Fortunately the very strong co-management measures in South Africa mitigate administrative problems to a large extent. The RSA land based inspection programme is also not as rigorous as in NZ and Alaska. Overall however, the three fisheries are all characterised by strong co-management measures, high levels of compliance and the ecosystems approach to scientific management.

It would be fair to say that the three fisheries are equally well managed on the basis of the best available ecosystems based science and the involvement of the industry in management and fisher compliance are hallmarks of the three fisheries. This ecosystem-based approach to managing the pollock, the hake and the hoki fisheries is an example of progressive fisheries management.

On the other hand, the Argentinean bottom trawl, hake fishery with an overall average score of 34.7% stands in stark contrast to the well-managed and MSC certified RSA hake, Alaskan Pollock and NZ hoki fisheries.

The Argentine hake (*Merluccius hubbsi*) is distributed over the continental shelves of Argentina and Uruguay. It is mainly found between 80 and 800 metres depth and between 35°S and 54°S. The fishery is a bottom-trawling fishery, which now produces around 60,000 tonnes annually, although the actual total catch by Argentina, Uruguay and Brazil are not known and there are no estimates for misreporting or discarding (Sustainable Fisheries Partnership 2015). The Uruguyan / Argentine Joint Fisheries Management Commission that has been in existence since the mid 1970s is responsible for management. Until around 2011the Commission has been rather ineffective. The stock has been overfished and depleted for the last 20 years. In 1998 the stock was declared to be in an emergency and 2013 data reveal that the SSB was at 31% of pristine, and current F is 174.4% above the target reference point (Sustainable Fisheries Partnership 2015).

The bottom trawling gear impacts the environment and there are no mitigation measures. Until recently, management was strongly politicized and not very scientific and the management strategies have not been precautionary. For example, the set TAC for 2015 was 157% higher (Figure 5) than the scientifically advised TAC (Sustainable Fisheries Partnership2015).

A Fisheries Improvement Plan for the fishery was developed by the Joint Management Commission in 2010. The FIP aims to implement a joint recovery plan, improve transparency of the Joint Management Commission, improve the robustness of the scientific approach, implement effective annual TACs following scientific recommendations, employ management measures in Argentina coherent with TAC measures, rebuilding of SSB (including reducing bycatch), clarify identification of common hake stocks in the southwestern Atlantic. Good progress is being made with respect to management procedures (CeDePesca 2014).

Bycatch levels are high and bycatch is mostly discarded and there are no discernible measures to reduce the impact on ETP species. From a management perspective the stock is only assessed on an irregular basis and there is no ecosystems approach, science based management plan. Although changes have been made, managemenet until recently was very much of a top down nature. MCS is weak and while there appear to be sea and land based observer programmes in place they do not appear to be very rigorous (Sustainable Fisheries Partnership 2015).

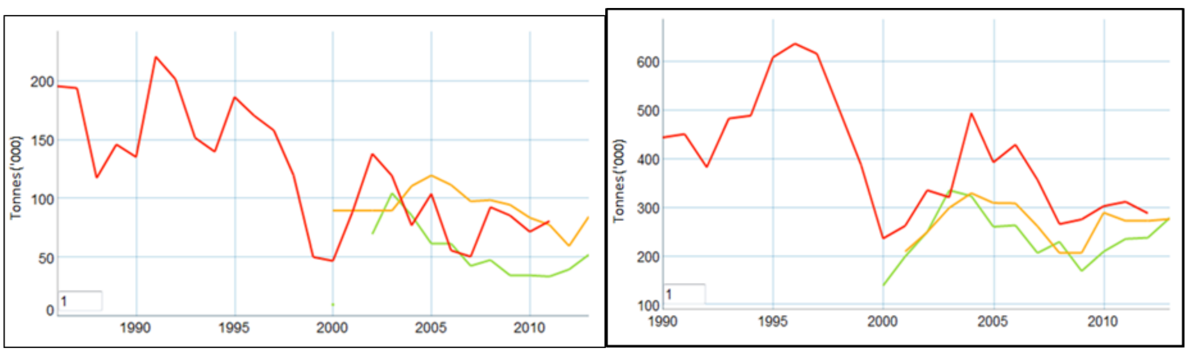

Figure 5. Catches (red line) and TAC (orange line) for the Argentina hake fishery north stock (left) and south stock (right). Note the TAC (orange line), set by management, is consistently above the scientific recommended TACs (green line) ((Sustainable Fisheries Partnership 2015).

Offshore trawl fisheries diagnostic

The SA hake, Alaskan Pollock and NZ hoki fisheries all have an average score over 80% and all are MSC certified (DAFF 2012, Deep Water Group 2013, Hutchings et al. 2009, MCS 2009a,b&c, MSC 2013, 2015). The three fisheries are fully and sustainably exploited (MSC 2009 a,b&c, MSC 2015). In comparison to the Argentine hake fishery the SA hake, the Alaska Pollock and the NZ hoki fisheries are managed in exemplary fashion. The Alaska pollock fishery is ranked in 1st place, followed closely by the NZ hoki and the SA hake fisheries. The review has shown that the scientific approach to management in the three fisheries, though ecosystems based and in accordance with the precautionary principle, is quite different but each is very effective in ensuring the high degree of sustainability of the fisheries. The value of active participation by industry in the management of these fisheries is very evident, particularly in view of the high degree of compliance and in some instances the implementation of voluntary ecosystem mitigation measures. The lower overall percent score of the RSA hake fishery (82%), in comparison to the Alaska Pollock fishery (92%) and the NZ hoki fishery (84%) is a result of a higher environmental impact (bottom trawling vs. midwater trawling) and less efficient MCS. The Alsakan Pollock fishery unquestionably has the most robust management system of the three fisheries and is an example of science-based, adaptive management at work. However, it should be noted that the sheer size and value of this fishery makes it possible to manage it in such a prototypical manner. The science underlying the management of the SA hake resources is of the highest international standard. Recent developments in the management initiatives of the Argentine/Uruguyan hake resource(s), which are geared towards rebuilding the stock are encouraging, but the fishery has a far way to go to be managed equitably and efficiently.

Table 5. Composite scoring table for the RSA hake, Alaska Pollock , New Zealand hoki and Argentine hake fisheries.

		Points	RSA	Alaska	NZ	Argentina
A	**Stock status** **MAX**	**10**	Hake	Pollock	Hoki	Hake
A1	Non-fully exploited (B>60% of pristine,CPUE>60% of initial rate,SSB>40% of unfished B)	**10**				
A2	Fully exploited (B=40-60% of pristine, CPUE = 40-60% of initial rate, SSB=20-40% of initial)	**8**	8	8	8	
A3	Stock status unknown but resource managed on a sustainable basis	**7**				
A4	Multi species fishery with under, fully and over exploited stocks	**6**				
A5	Over exploited (B<40% of pristine, SSB<20% of unfished B, but showing signs of recovery)	**4**				4
A6	Over exploited (same as above but B, SSB, CPUE and size composition trends decreasing)	**1**				
B	**Ecosystem impact mitigation** **MAX**	**20**				
B1a	Low habitat impact	**3**		3		
B1b	Medium habitat impact	**2**			2	
B1c	High habitat impact	**1**	1			1
B2a	Habitat impact mitigation measures implemented or not required	**2**	2	2	2	
B2b	No habitat impact mitigation measures implemented	**1**				1
B3a	Bycatch <5% of catch	**3**		3		
B3b	Bycatch <10% of catch	**2**				
B3c	Bycatch >10% of catch	**1**	1		1	1
B4b	Impact on ETP species understood / studied and mitigation measures implemented	**2**	2	2	2	
B4c	Impact on ETP species not well understood and no mitigation measures implemented	**0**				0
B5a	Voluntary habitat/ecosystem impact mitigation measures implemented	**3**	3			
B5b	No voluntary habitat/ecosystem impact mitigation measures implemented	**1**		1	1	1
B6a	By catch management plan in place	**2**	2	2	2	
B6b	No by catch management plan	**0**				0
B7a	Fish bycatch mitigation measures implemented	**2**	2	2	2	
B7b	No fish bycatch mitigation measures implemented	**0**				0
B8a	Fish bycatch mainly retained	**3**	3	3	3	
B8b	Fish bycatch partially retained/discarded	**2**				
B8c	Fish bycatch mainly discarded	**1**				1
C	**Effective Management** **MAX**	**20**				
C1a	Regular (annual or biennial) assessments of B, SSB and F or other	**3**	3	3	3	
C1b	Irregular assessments B, SSB and F or other	**2**				2
C1c	No assessments	**0**				
C2a	Science based management plan in place in accordance with the precautionary principle	**2**	2	2	2	
C2b	Major differences between scientific advice and management plans	**0**				0
C3a	Ecosystems approach to management applied or actively researched	**2**	2	2	2	
C3b	Ecosystems approach to management neither applied nor researched	**0**				0
C4a	Best management methods employed (TAC,TAE,ITQs, Closed seasons / areas)	**2**	2	2	2	
C4b	Non optimal management measures employed	**1**				1
C5a	Industry actively involved in the management of the resource	**2**	2	2	2	
C5b	Industry not actively involved in the management of the resource	**0**				0
C6a	Fishers compliant (Catch vs TAC, over or under reporting of catches)	**2**	2	2	2	
C6b	Fishers not very compliant	**1**				1
C7a	Strong MCS measures employed	**2**		2	2	
C7b	Weak MCS measures employed	**1**	1			1
C7c	No MCS measures employed	**0**				
C8a	Sea based observer programme in force (ALL Vessels Full Time)	**3**		3		
C8b	Sea based observer programme in force (SOME Vessels Full Time	**2**			2	
C8c	Sea based observer programme in force (SOME Vessels Occasionally)	**1**	1			1
C8d	No sea based observer programme	**0**				
C9a	Landbased inspection programme in force (ALL landings)	**2**		2	2	
C9b	Landbased inspection programme in force (SOME landings)	**1**	1			1
C9c	No landbased inspection programme in force	**0**				

2. The "small pelagic" fisheries

The South African small pelagic fishery was benchmarked against the Peruvian anchovy fishery, the Argentinian anchovy fishery, which is MSC certified, and the Chilean Jack mackerel fishery. The comparative scores of the four fisheries are shown in Figure 6 and the actual scores per assessment criterion are shown in Table 6. Table 7 presents the scores for all indicators.

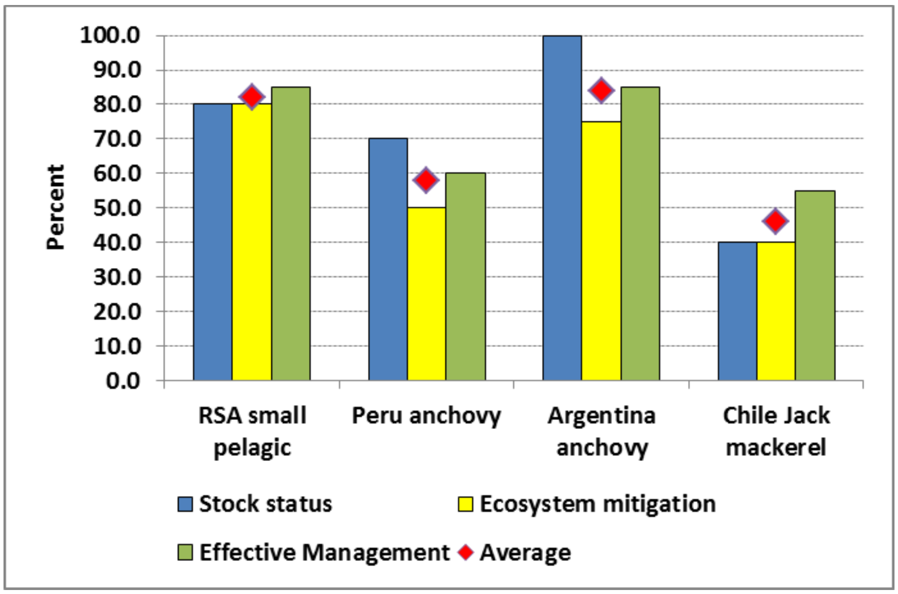

Figure 6. Benchmark criteria and average percent score for the four "small pelagic" fisheries.

Table 6. Benchmark criterion points for the four "small pelagic" fisheries.

POINTS	RSA small pelagics	Peru anchovy	Argentina anchovy	Chile Jack mackerel
Stock status (10)	8	7	10	4
Ecosystem mitigation (20)	16	10	15	8
Effective Management (20)	17	12	17	11
Total score (50)	41	29	42	23
Average	13.7	9.7	14.0	7.7
MSC certified	No	No	Yes	No
Ranking on average score	2	3	1	4

Forage fish worldwide are characterized by highly variable recruitment, which results in large fluctuations in population size. The primary challenge for fisheries managers and policymakers is to determine a safe level of catch that also accounts for the important ecological role that forage fish play in the larger marine environment by the implementation of an ecosystems-based approach to fisheries management (Oceana 2013).

The South African small pelagic, purse seine fishery is the country's largest fishery in terms of annual landings and the second-most valuable (van der Lingen and Hugget, 2003). Over the past 50 years, the small pelagic fishery has made large catches averaging around 300 000 tonnes per annum. Sardine dominated the catches initially, but overfishing of this population in the 1960s led to a stock collapse and the fishery changed to smaller meshed nets in 1964 to target the smaller anchovy. Anchovy have dominated catches since, but catches of sardine have generally increased since 1990 (van der Lingen & Hugget, 2003). As mentioned above, the fishery is a purse seine fishery. Mid water trawling and paired midwater trawling gear, fitted with grids and seal escape hatches, has recently been tested with variable degrees of success. Anchovy, horse mackerel and (most) round herring are processed into fishmeal, fish oil and fish paste in factories located mostly on the West Coast, whereas sardine are canned or frozen for human consumption, pet food and for bait (DAFF 2012).

The science underlying the management procedures is described by Hutchings et al. (2009) and DAFF (2012) and the fishery's management procedure is complex and accounts for both target and bycatch species.

Juvenile (approximately six months old) anchovy (*Engraulis encrasicolus*) and adult sardine (*Sardinops sagax*) are the major targets of the fishery and together account for around 75% of total landings, but adult round herring (*Etrumeus whiteheadi*) are also targeted, and juvenile horse mackerel (*Trachurus trachurus capensis*), sardine and round herring are taken as bycatch in anchovy-directed fishing operations. Anchovy and sardine have alternated as the dominant component of the fishery, although in recent years landings of the two species have been similar. Seventy per cent of the anchovy catch is taken off the west coast and comprises young fish migrating from the west coast nursery grounds to the south coast spawning grounds, whereas sardine have been caught off the west, southwest and south coasts during different periods of the fishery. Anchovy and sardine stocks show a high degree of interannual and decadal-scale variability in population size. This high variability means that accurate estimates of recruitment strength and population size are required annually to set total allowable catch levels. Both fishery-dependent and fishery-independent data are collected as model inputs. Fishery dependent data are collected from landing sites and include catch weight, species composition, and catch location. Data on fish length, weight, sex, gonad maturity stage and gonad mass, otoliths (for age determination), and condition (equivalent to body lipid content) are collected for sardine from commercial catch samples. Catch-at-age and weight-at-age data for both species are generated from age–length keys derived from commercial catch samples. Fishery-independent hydroacoustic surveys of the SA small pelagic resource have been ongoing since 1983. Annual biomass estimates of anchovy and sardine spawner biomass have been made every November, since then. The collection of ichthyoplankton samples during spawner biomass surveys permitted estimates of anchovy spawner biomass using the daily egg production method (DEPM). The DEPM estimates and acoustic survey estimates for anchovy spawner biomass showed good agreement over a period of ten years, leading to discontinuation of the DEPM due to the additional work load required to produce two essentially similar biomass estimates. Information on temperature, salinities, oxygen and plankton is also collected during fishery-independent hydro-acoustic surveys to understand ecosystems changes and shifts (Hutchings et al. 2009). There has been a steady increase in estimated round herring recruitment and biomass since the inception of the hydro-acoustic surveys in 1983 (DAFF 2012).

Observers on boats have been deployed in the pelagic fishery since 1999, to provide data relating to catch weight and locality, catch composition, and length frequencies of important species, in addition to collecting some biological data. Unfortunately the national observer programme and although it covered only 8% of fishing trips (Hutchings et al. 2009), was stopped in 2011, but will hopefully be re-instated in 2015. The industry has however independently maintained the observer programme, albeit on a smaller scale and the land-based inspection programme ensures that fishers comply with the annual permitted catch levels. However, observer data in the past has suggested that discarding occurs because of high bycatch levels and/or fish of an inappropriate size for canning (Hutchings et al. 2009). The current extent of dumping is unknown. The impact of the fishery on ETP species is low and seals are released from the nets.

South Africa's small pelagic fishing sector is managed by catch control, and uses an Operational Management Procedure (OMP) to make recommendations regarding separate annual total allowable catch (TAC) levels for anchovy, sardine and round herring. The operational management procedure was developed to avoid exposing the resource to undue risk of depletion (Fairweather et al. 2006). Because small pelagics school together as juveniles, catches of both anchovy and sardine cannot be simultaneously maximised, since large anchovy catches result in a high juvenile sardine by-catch (Faiweather et al. 2006). The OMP also includes constraints on the extent to which TACs can vary from year to year in order to enhance industrial stability.

The OMP sets an annual TAC directed at adult sardine and an annual 'initial' TAC for anchovy, both based on adult population sizes estimated from the spawner biomass survey conducted between October and December in the preceding year. A 'final' anchovy TAC is set mid-year, depending on anchovy recruitment strength observed during the May/ June recruit biomass survey (DAFF, 2012). An 'initial' total allowable by-catch (TAB) limit set for juvenile sardine at the start of the year is also revised to a final TAB, depending on recruitment strength. A fixed Precautionary Upper Catch Limit (PUCL) of 100 000 tonnes is set for round herring, irrespective of its population size and a PUCL of 5 000 tonnes for by-catch of juvenile horse mackerel (also taken in anchovy directed fishing) is also applied (DAFF, 2012).

The revision of the 2011 OMP has been completed in consultation with the industry and was implemented in 2013. A number of constraints and control parameters are in place in the OMP to ensure maximum industry stability, without exceeding generally accepted levels of risk for the two main pelagic species. These constraints and control parameters include maximum and minimum TACs for sardine and anchovy, maximum year-on-year deviations in TACs for both species, and the proportions of the total biomass that may be taken of each species. In addition, the revised OMP will also consider the needs of top predators, in this case as a first step, taking into account the interactions between the fishery and penguins. These, and other constraints, have been tested during exhaustive simulation studies (Oceana 2013).

The Argentine anchovy (*Engraulis anchoita*) fishery is a small fishery in the Southwest Atlantic Ocean with annual landings of around 20,000 tonnes (SeafoodSource 2011) that occurs from around Vitória in Brazilian waters to the San Jorge Gulf (47º S) in Argentine waters (Madureira et al. 2009). The fishery was MSC certified in 2011 (MSC 2015). Argentina is a pioneer in the production of anchovy for human consumption and this industry is directed to both the domestic and export markets. More than 80 percent of the catch is salted and the remainder is value-added. Value added products derived from the fishery include anchovy fillets in oil, vacuum-packed anchovy fillets, anchovies in brine, salt-cured anchovies, anchovy fillet marinated in vinegar and whole frozen anchovies (Madureira et al. 2009). Eighty percent of the Argentine anchovy catch is exported, with the most important export markets being Spain, Peru and Morocco. In 2005, Argentina exported anchovy based products to a value of US$26 million (Madureira et al 2009).

The Argentina anchovy stock north of 41° S remains "healthy" (Hansen et al., 2014, Prentski 2014). In fact, according to both Pajaro et al. (2009) and Hansen et al. (2014) the stock is under exploited. However managers are maintaining a precautionary approach and therefore recommended a 120,000 t maximum catch for 2014 (Prenski et al. 2014). The catch for 2014 was extremely low and did not exceed 12,500 t. This was ascribed to oceanographic conditions and stock behavior. This resulted in gear change and the anchovy fleet began targeting hake (*M. hubbsi*).

The Argentinean fishery is a mid-water trawl fishery so habitat impacts are low to medium. The net is made of 4mm diameter nylon and has a total length of between 60 to 70 m. Mitigation measures to minimize the impact on ETP species are better developed in South Africa than in Argentina. The Argentina fishery has a formal observer programme, although on board observer frequency is very low (Prenski et al. 2014) and does not appear to be well organized.

Abundance is estimated using hydro-acoustic surveys and daily egg production methods by Brazilian, Uruguayan and Argentine research institutions. Annual abundance estimates over the entire distribution range of the species vary between 600 000 tonnes and 4.5 million tonnes. There are significant regional and yearly variations in biomass estimates along the coastal shelves of the three countries (Prenski et al. 2013). Fishing takes place predominantly between July and November. Alternative stock assessment models that take into account recruitment-environment coupling and the ecological / trophic role of anchovy are now being considered. Exploitation of anchovy has also recently started in southern Brazil, so there is a need for a better understanding of population structure and dynamics (Carvalho and Castello 2013).

Managers are mindful of the ecosystems approach and attention is now being paid to impacts on ETP species and marine mammals, although there are no plans to implement mitigation measures. There were no research surveys between 2008 and 2012. The historical catches of Argentina anchovy by the Argentinean fleet and the Uruguayan fleet are approximately 4 times lower than the F_{safe} level, which in 2012 was estimated by INIDEP at 160,000 tonnes. However, since 1994 the maximum biological acceptable catch of anchovy was again set at 120 000 tonnes for 2012. Harvest control rules are consistent with the harvest strategy (Prenski et al. 2014).

Bycatch appears to be less than 3% and much of it is retained. A bycatch management plan is being developed but has not yet been implemented (Prenski et al. 2014). Seabirds, such as Magellanic penguins, black-browed albatross, shearwaters black head and white-chinned petrels have been recorded in the bycatch. However, preliminary analysis suggests that the mortality rate is very low at around 0.70 birds per day of fishing. The latest MSC assessment (Prenski et al. 2014) however recommends that serious efforts be made to monitor, quantitatively assess and report more comprehensively on the impact of the fishery on ETP species. The impact of the fishery on sharks and marine mammals is negligible (Prenski et al. 2014).

Argentinian research institutions are working on trophic interactions between this fishery and other fisheries and in particular the *M. hubbsi* fishery. Closed areas to protect cartilaginous species have also been introduced. In comparison to the South African management paradigm the Argentinian system is much less sophisticated and which, until recently, was not transparent nor integrated with industry players and lacked hard data for setting of target and limit reference points

The Peruvian anchovy fishery is the world's largest small pelagic fishery and is located in the productive Humboldt Large Marine Ecosystem (HLME). There are four different anchovy (*Engraulis ringens*) stocks off the South Eastern Pacific margin, spanning from Peru down to Chile. These are:

1. the Northern-Central Peruvian stock, managed by Peru;
2. the Southern Peru/Chilean Regions XV-I-II stock, managed by both Peru and Chile;
3. the Chilean fishery units III-IV stock, managed by Chile, and,
4. the Chilean fishery units V-X stock, also managed by Chile.

The straddling nature of the stocks makes management very complex. In Peru the responsible management agencies are the Ministry of Production and the Vice-Ministry of Fisheries, which are advised by the marine research institute IMARPE. IMARPE cooperates with the Chilean Fishery Research and Development Institute (IFOP) to monitor the fishery that straddles the Peru–Chile border.

This comparative review is limited to the Northern-Central Peruvian stock. Catches from this stock make up ca. 99% of total anchovy landings.

Similar to other small pelagics the Peruvian anchovy stock fluctuates because of natural events, which occur seasonally, annually, inter-annually and on inter- decadal scales. One of the most dramatic environmental events affecting the HLME is the occurrence of El Niño (IFFO, 2009). The Peruvian anchovy fishery produces 30% to 35% of the world's fishmeal and fish oil and operates mainly in the area between Paita and the southern maritime limit (the demarcation line between the Peruvian and Chilean waters). The fishery uses purse seine nets and so habitat impact is low and industrial vessels are banned from operating within 10 nm of the coast .

An effective precautionary, ecosystems based management system is in place to manage the Peruvian stock. As a consequence of a dramatic drop in catches Peru closed the fishery at the end of 2014 until stocks recover. Due to very high inter-annual fluctuations it is not possible to calculate a long-term optimal catch for the fishery and management strategies for the fishery need to be adaptive and flexible with a rapid response time (IFFO, 2009). The fishery is fully exploited at a low level of uncertainty (FAO 2011).

IMARPE conducts acoustic surveys to assess the fish populations three times a year as well as oceanographic and plankton surveys to estimate fish abundance based on egg and larvae density. Further, satellite data provides information on the spatial distribution, size structure and school depth of the fish, water temperature and real time verification of landings. IMARPE, which falls under the Vice-Ministry of Fisheries, uses this information to recommend annual management strategies to the Ministry of Production (IFFO, 2009), which signs off all managerial decisions. So while the fishery is relatively well managed, the industry itself is largely excluded from making any management decisions, the reasons for which are not entirely clear.

Stock assessments are carried out using virtual population analysis (VPA) and integrated population models (Díaz, 2009), spawning areas are identified by plankton, egg and larval surveys and Spawning Stock Biomass (SSB) is estimated using the Egg-Production Method (EPM) (IMARPE, 2014b,c). Biomass estimates are combined with real-time estimated size structure, reproductive indexes, oceanographic and satellite data to monitor the El Niño/La Niña influence in anchovy along the Peruvian coast. Stock assessment findings have not been made available since 2010 and there are no fishing mortality estimates for recent years, so the uncertainty surrounding the status of the stock is considerable. Never the less, precautionary management measures since 2012 are considered to have contributed to the improvement of the stock (IMARPE 2014b).

Even though reported landings have been below set TACs, overall doubts have been expressed over the reliability of landing controls. Since 2004, independent audit companies monitor and record landings. All landing sites (296) are covered by this programme. Between 5-10% of the vessels carry on-board observers at any given time and the fishery is known to impact on several ETP species (sea turtles, marine mammals, seabirds and sharks) most of which are released alive (Young and Lankester, 2013). While the fishery has a legal bycatch limit of 5% (CeDePesca, 2010), there is considerable uncertainty regarding bycatch and discard rates. Non-reported discards may have increased in recent years, incentivized by a maximum allowable landing of juveniles (10% of catch) (PRODUCE, 2012c,d). It was reported that bycatch by the industrial fleet targeting anchoveta is around 3%, excluding Chub mackerel (*Scomber japonicus*) and Chilean jack mackerel. Compliance by the fleet is considered high, but with a high level of uncertainty (IMARPE 2014a). It has been suggested that the main threat posed by the Peruvian anchovy fishery to ETP species is the reduction of food availability due to heavy fishing, that would impact on the breeding success of seabirds (Gislason, 2003).

The Chilean Jack mackerel stock straddles international as well as Chilean and Peruvian waters and is exploited by vessels under the flags of China, Vanuatu, the EU, Faroe Islands, South Korea, Belize, and Russia competing with Chilean and Peruvian traditional purse-seiners. Asian and European companies are also operating trawlers under the Peruvian flag. The fishery collapsed in 2008. Historically, Chile has accounted for 80 percent of total landings, reaching around 4 million tonnes in the 1990s, but by 2011 landings decreased by 75 % to about 500,000 tonnes. Most of the product from Chile and Peru is now exported frozen or canned (Sustainable Fisheries Partnership 2013).

Recently, a combination of depletion and migratory phenomena, not yet well understood, has impacted significantly on this international fishery. In 2010, the South Pacific Regional Fisheries Management Organization started a process to assess and manage the Chilean jack mackerel stock in national (Ecuador, Peru, Chile) and international waters. The stock assessment model and the input data quality are considered adequate, although there is still uncertainty about the stock structure. A FIP has been adopted although a harvest control rule to be used in TAC-setting is still under review (Sustainable Fisheries Partnership 2013).

The stock structure of Chilean Jack mackerel in the southeast Pacific is not clear, although research based on genetic (Cárdenas et al., 2009) and otolith (Ashford et al., 2011) analyses supports the existence of a single trans-zonal population (Gerlotto et al., 2012; SPRFMO, 2013a,b). While more conclusive evidence is not available the South Pacific Regional Fisheries Management Organization (SPRFMO) currently works under two competing hypotheses: that there are separate Peruvian and Chilean stocks and that there is a single shared stock, all straddling the high seas (SPRFMO, 2014a). However, the Chilean stock assessment model used by the Fisheries Development Institute (Instituto de Fomento Pesquero), assumes a single stock of jack mackerel inside and outside the EEZ off Chile as far as 120°W.

Since 1998, a series of drastic management decisions have been made, such as the reduction in fishing effort by more than 50%, setting of conservative TACs, the introduction of individual transferable quotas. However, implementation of and compliance with these recommendations is periodically ignored (Sustainable Fisheries Partnership 2015). The annual research budget has also been increased to increase hydro-acoustic surveys and egg production studies. Since 2010, a joint Jack Mackerel stock assessment has been conducted, including fisheries independent and dependent data from each fishing country in a statistical catch-at-age model performed by the South Pacific Regional Fisheries Management Organization (SPRFMO)'s Scientific Committee (SC). The models consider the two working hypotheses on stock structure: 1) two separate stocks, Peruvian/northern stock and Chilean/southern stock which straddle the high seas; 2) a single shared stock which straddles the high seas (SPRFMO, 2014a). Hypothesis 2 has been used as the basis for the advice, as it results in more conservative catch levels (Sustainable Fisheries Partnership 2015).

Jack mackerel landings peaked at 4.7 million tonnes in 1995. In 2012 the total catch was just over 417,000 tonnes for the entire SE Pacific stock. Updated assessment results indicate that the current biomass is estimated to be between 8% and 16% of the pristine spawning biomass. The current estimated SSB is below the threshold of 20% of unfished spawning biomass. Recent reports indicate that the biological status of the Chilean jack mackerel stock in the South Pacific is poor and continues to be overexploited (Sustainable Fisheries Partnership 2015).

In 2011, international participants agreed on interim management measures that would limit the 2011 catches of Chilean jack mackerel to 60% of the 2010 levels (750 000 tonnes) to a total of 450 000 tonnes. However, 605 817 tonnes was then caught with Peru, Ecuador, Russia and Korea accounting for the excess catches, raising issues of non-compliance (SPRFMO, 2008).

Since around 2000, the TAC set by management has been higher than that recommended by scientists and fishing mortality is significantly higher than the F target reference point (Sustainable Fisheries Partnership 2015) and this is unfortunate (see Figure 7)

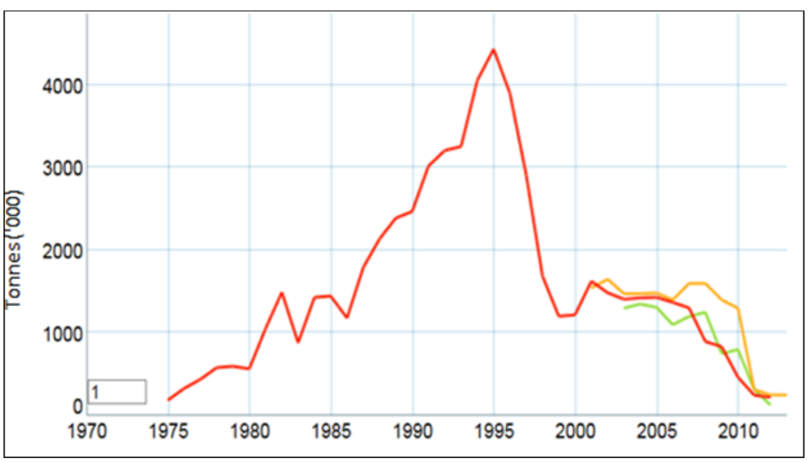

Figure 7. Catches (red) and TACs (orange) for the Chilean Jack Mackerel. The green line shows the TACs recommended by the scientists, while orange shows actual set TACs. (source: Sustainable Fisheries Partnership 2015)

There are some instances of non-compliance with the SPRFMO's Conservation and Management Measures, particularly as to timely reporting (SPRFMO, 2014c). Vessel Monitoring Systems (VMS) are being implemented according to standard requirements defined at the SPRFMO level. Peru mandates that 20% of its vessels carry an observer but reported 100% coverage in the 2013 jack mackerel fishery (SPRFMO, 2014c). Chilean fishing trips carried observers in 9.1% of high seas trips and 15.2% of trips within the Chilean EEZ (SPRFMO, 2014e). The European Union reported 13% coverage, China 0%, and Korea and Vanuatu 100% in 2013 (SPRFMO, 2014c, Sustainable Fisheries Partnership 2015).

The purse seine and pelagic trawling gear used in this fishery has no interaction with the seabed ecosystem (SPRFMO 2013d). An assessment of the Impact of Fishing on Non-target, Associated or Dependent Species is being undertaken for all fishing fleets operating in the Convention area, to determine the impact of the fishery on bycatch species (SPRFMO, 2013a). Very little is known of the level of interaction of the fishery with ETP species. While there have been sightings of seabirds in purse seine nets the level of interaction of the fishery with ETP species appears to be low but reporting is inadequate.

"Small pelagic" diagnostic

The results show that the South African small pelagic fishery is ranked second after the MSC certified Argentina anchovy fishery and this is only as a consequence of the non-fully exploited status of the Argentine anchovy stock. However, in terms of effective management and ecosystem issues the SA fishery is ranked in first place. The Peruvian anchovy fishery, one of the largest small pelagic fisheries in the world, lags behind mainly because of lower ecosystems impact mitigation and effective management scores. The Chilean Jack mackerel fishery is the least well managed of the four fisheries. The SA small pelagic fisheries management plan that takes into account the various bycatch species such as redeye and juvenile horse mackerel is far superior to the management systems of any of the other small pelagic fisheries considered here. For this reason the ecosystem impact mitigation criteria score for the SA fishery is higher than the score for the Argentinean fishery. The Peruvian anchovy fishery, the largest fishery in the world, is not as well managed as the former two fisheries and with respect to ecosystem impact mitigation measures is far behind the others. In comparison to the other three small pelagic fisheries the Chilean Jack mackerel fishery is severely depleted, but recovering. With respect to management systems as well as ecosystems mitigation measures it lags far behind the other three fisheries and hence ranks fourth.

Table 7. Composite scoring table for the RSA small pelagic, Peru anchovy , Aregentina anchovy and the Chilean Jack mackerel fisheries.

		Points	SA	Peru	Argentina	Chile
A	**Stock status MAX**	**10**	Small pelagics	Anchovy	anchovy	Jack Mackerel
A1	Non-fully exploited (B>60% of pristine,CPUE>60% of initial rate,SSB>40% of unfished B)	**10**			10	
A2	Fully exploited (B=40-60% of pristine, CPUE = 40-60% of initial rate, SSB=20-40% of initial)	**8**	8			
A3	Stock status unknown but resource managed on a sustainable basis	**7**		7		
A4	Multi species fishery with under, fully and over exploited stocks	**6**				
A5	Over exploited (B<40% of pristine, SSB<20% of unfished B, but showing signs of recovery)	**4**				4
A6	Over exploited (same as above but B, SSB, CPUE and size composition trends decreasing)	**1**				
B	**Ecosystem impact mitigation MAX**	**20**				
B1a	Low habitat impact	**3**	3	3	3	3
B1b	Medium habitat impact	**2**				
B1c	High habitat impact	**1**				
B2a	Habitat impact mitigation measures implemented or not required	**2**				
B2b	No habitat impact mitigation measures implemented	**1**	1	1	1	1
B3a	Bycatch <5% of catch	**3**			3	
B3b	Bycatch <10% of catch	**2**	2	2		2
B3c	Bycatch >10% of catch	**1**				
B4b	Impact on ETP species understood / studied and mitigation measures implemented	**2**	2	2	2	
B4c	Impact on ETP species not well understood and no mitigation measures implemented	**0**				0
B5a	Voluntary habitat/ecosystem impact mitigation measures implemented	**3**				
B5b	No voluntary habitat/ecosystem impact mitigation measures implemented	**1**	1	1	1	1
B6a	By catch management plan in place	**2**	2		2	
B6b	No by catch management plan	**0**		0		0
B7a	Fish bycatch mitigation measures implemented	**2**	2		2	
B7b	No fish bycatch mitigation measures implemented	**0**		0		0
B8a	Fish bycatch mainly retained	**3**	3			
B8b	Fish bycatch partially retained/discarded	**2**				
B8c	Fish bycatch mainly discarded	**1**		1	1	1
C	**Effective Management MAX**	**20**				
C1a	Regular (annual or biennial) assessments of B, SSB and F or other	**3**	3		3	
C1b	Irregular assessments B, SSB and F or other	**2**		2		2
C1c	No assessments	**0**				
C2a	Science based management plan in place in accordance with the precautionary principle	**2**	2	2	2	2
C2b	Major differences between scientific advice and management plans	**0**				
C3a	Ecosystems approach to management applied or actively researched	**2**	2	2	2	2
C3b	Ecosystems approach to management neither applied nor researched	**0**				
C4a	Best management methods employed (TAC,TAE,ITQs, Closed seasons / areas)	**2**	2	2	2	
C4b	Non optimal management measures employed	**1**				1
C5a	Industry actively involved in the management of the resource	**2**	2		2	
C5b	Industry not actively involved in the management of the resource	**0**		0		0
C6a	Fishers compliant (Catch vs TAC, over or under reporting of catches)	**2**	2		2	
C6b	Fishers not very compliant	**1**		1		1
C7a	Strong MCS measures employed	**2**				
C7b	Weak MCS measures employed	**1**	1	1	1	1
C7c	No MCS measures employed	**0**				
C8a	Sea based observer programme in force (ALL Vessels Full Time)	**3**				
C8b	Sea based observer programme in force (SOME Vessels Full Time	**2**		2		
C8c	Sea based observer programme in force (SOME Vessels Occasionally)	**1**	1		1	1
C8d	No sea based observer programme	**0**				
C9a	Landbased inspection programme in force (ALL landings)	**2**	2		2	
C9b	Landbased inspection programme in force (SOME landings)	**1**		1		1
C9c	No landbased inspection programme in force	**0**				

3. The “large pelagic” fisheries

Four “large pelagic” fisheries were compared to each other with respect to stock status, ecosystems mitigation measures and effective management. These included the South African tuna longline and pole fishery, the Japanese coastal tuna longline and pole fishery, the USA albacore troll and pole fishery and the Indonesian longline and handline tuna fishery. The percent scores of the four fisheries are shown in Figure 8 and the actual scores per assessment category are shown in Table 8 and Table 9 shows the indicator scores in each of the three evaluation criteria.

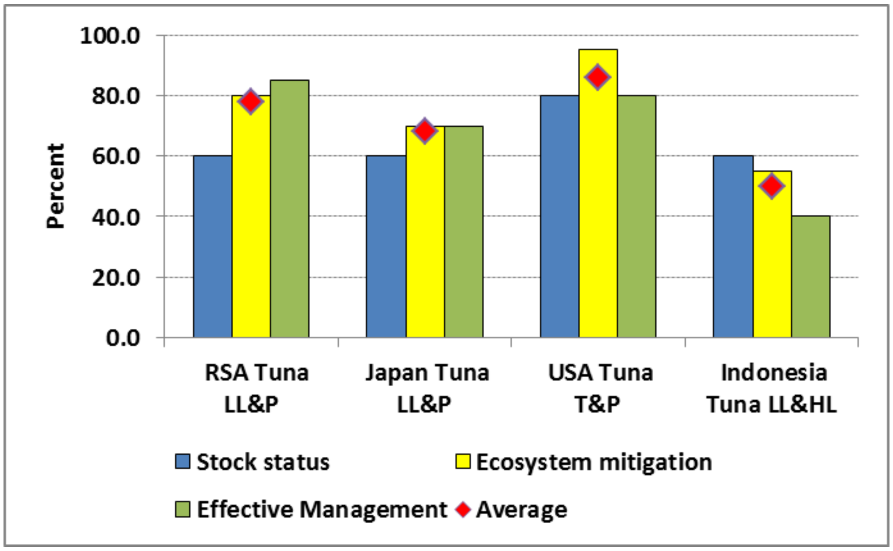

Figure 8. Benchmark criteria and average percent score for the four large pelagic fisheries.

Table 8. Benchmark criterion points for the four large pelagic fisheries.

POINTS	RSA Tuna LL&P	Japan Tuna LL&P	USA Tuna T&P	Indonesia Tuna LL&HL
Stock status (10)	6	6	8	6
Ecosystem mitigation (20)	16	14	19	11
Effective Management (20)	17	14	16	8
Total score (50)	39	34	43	25
Average	13.0	11.3	14.3	8.3
MSC certified	No	No	Yes	No
Ranking on average score	2	3	1	4

The South African large pelagic fishery has two commercial and a recreational fishing components that target tuna and tuna-like species in the Atlantic and Indian Oceans. The commercial fisheries are the longline and the pole fishery. Commercial longlining for tuna in South Africa started in the 1960’s with catches reaching ~2000 MT. Southern bluefin tuna and albacore comprised the bulk of the catch. The fishery ceased to exist after the mid 1960's, as a result of a poor market for low quality bluefin and albacore tuna landed by South African fishers. Interest to target tuna using longline gear re-emerged in 1995 when a joint venture with a Japanese vessel confirmed that tuna and swordfish could be profitably exploited within South Africa's waters. Thirty experimental longline permits were issued in 1997 to develop a pelagic catch performance for South Africa such that the country could receive equitable quotas from ICCAT and the IOTC and the CCSBT. Catches peaked at over 2 500 t during the experimental phase of the fishery, with swordfish comprising the bulk of the catch. This led to sharp declines in swordfish abundance in South Africa's EEZ. There has been intermittent participation by foreign flagged vessels in the SA long line fishery, mainly to improve the local catch performance and to transfer long lining skills to SA fishers (DAFF 2012a, 2012b). In 2011, the pelagic shark long line fishery was stopped and pelagic shark long line rights holders were merged with the tuna / swordfish longline fishery and targeting of pelagic sharks, mainly blue and mako sharks (Petersen et al. 2009), was no longer allowed. Other bycatch species in the long line fishery include seabirds and turtles but by catch management plans have resulted in significantly reduced ETP species mortaliy (see below).

The South African tuna pole fishery has been operating since 1980 and the fishing grounds are situated along the west coast of South Africa. The tuna pole fishery traditionally targets high volume, low value albacore *Thunnus alalunga* along the west coast of South Africa for canning. Since 2003, this sector has diversified with some vessels targeting low volume, high value yellowfin tuna *T. albacares* for sashimi markets. Due to the seasonality of tuna in South Africa's waters the tuna pole fishery was also allowed access to snoek *Thyrsites atun* and yellowtail *Seriola lalandi*. Access to these traditional linefish species has caused conflict with the linefish sector. A minimum vessel size was also stipulated, i.e. only vessels >10 m will be allowed into the fishery unless tuna performance is demonstrated. The fishery is managed by a TAE of 200 vessels (3 600 crew) as albacore (the primary target species) was considered under-exploited. Annual catches of albacore have fluctuated around 3 000 tonnes and is largely dependent on the availability of albacore in near-shore waters from October to May. Due to the seasonality of the fishery, up to 40% of rights holders are involved in other sectors (DAFF 2012b).

Stock assessments, developing control measures and country allocations for the Atlantic and Indian Ocean stocks of highly migratory tuna and tuna-like species are the responsibility of the International Commission for the Conservation of Atlantic Tunas(ICCAT) and the Indian Ocean Tuna Commission (IOTC), while stock assessments for southern bluefin tuna are conducted by the Commission for the Conservation of the Southern Bluefin Tuna (CCSBT). A stock assessment for yellowfin tuna conducted by ICCAT in 2011 (using catch-and-effort data through 2010) indicated that the stock in the Atlantic Ocean was overfished. The last full Southern Atlantic albacore stock assessment was conducted by ICCAT in 2011 and suggests that the stock in the Atlantic is both overfished and experiencing overfishing. In the Indian Ocean it is not over fished (Seafood Watch, 2007). Swordfish stock assessments were conducted by ICCAT and IOTC in 2013 (IOTC 2013) and indicated that the stock in the Atlantic Ocean and the Indian Ocean are not overexploited. The latest stock assessment of Bigeye tuna in the Atlantic Ocean was conducted in 2010 (using catch data up to 2009), and indicated that the stock is optimally exploited. The status of the Southern Bluefin stock is overexploited and the latest stock assessments indicate that the spawning stock biomass (SSB) is very low. Given that some species are optimally exploited and others over exploited the SA large pelagic resources as a whole where allocated a stock status score of 6. Given that most tuna and tuna-like stocks are optimally- to over-exploited and that South Africa has a vessel capacity limit in the Indian Ocean the number of longline vessels targeting large pelagics has been restricted to 50 at this stage of its development. For the same reasons, as well as other concerns, the TAE for the pole fishery has been frozen at the current level of effort.

South Africa had an established onboard scientific observer programme to obtain length frequencies, biological samples, and fisheries information on target and bycatch species. The observer coverage was aimed at 20% for domestic vessels and 100% for foreign-flagged vessels. Because of administrative blunders the observer programme for domestic vessels came to an end in March 2011. Currently, 100% observer coverage is achieved on foreign flagged vessels but there has been no coverage on domestic vessels since March 2011.

Ecosystems based research on large pelagics in South Africa is a relatively recent initiative but it is gaining momentum. Various projects are currently underway, ageing, swordfish genetics, movement behavior using PAT, PSAT and SPOT tags, yellowfin stock delineation, and the effect of live bait extraction on the small pelagic sector. South Africa is one of the major participants in Component 4 of the SWIOFP (South West Indian Ocean Fisheries Programme), which aims to better understand the movement patterns of highly migratory large pelagic species. In addition the South African Fisheries Department is cooperating with various bodies (WWF, University of Washington Sea Grant, and Birdlife SA) to assess the impact of longline fisheries on seabirds, turtles and sharks, and to optimise various mitigation and management measures (DAFF 2012b).

A National Plan of Action (NPOA) for seabirds was published in 2008, which aimed to reduce seabird mortalities below 0.05 seabirds per 1 000 hooks. The mitigation measures are stringent. Once a vessel reaches 25 birds killed in a year, it must adopt additional mitigation measures by flying a second tori line and it has to place additional weights on to each branchline. Since the implementation of seabird mitigation measures and the stringent monitoring thereof seabird mortality rates has reduced by more than an order of magnitude. The seabird mortality rate for 2012 was for the first time in history below the stipulated rate of 0.05 birds/1000 hooks (Maree et al. 2014 and Birdlife Africa). Except for ecosystem effects the impacts of the fish methods are negligible. A domestic shark bycatch management plan has been instituted where a bycatch limit has been set at 2 000t dressed weight. Once this limit is reached, fishing in the large pelagic fishery stops.

The permit conditions for the Tuna long line and pole fisheries (DAFF 2012) include amongst others;

- All fish have to be discharged in the presence of a Fishery Control Officer (FCO) who signs off on the landing declaration.
- Catch statistic forms have to be filled out for every trip.
- Trip summaries are submitted after every trip.
- Tuna pole vessels are requested to submit yellowfin tuna length frequency data with their catch statistic forms.

The Japanese large pelagic fisheries can be divided into three separate sectors: the distant-water fisheries, the offshore fishery and the coastal fisheries. All fishing operations by the Japanese coastal and offshore longline and pole and line vessels occur in the western Pacific, and the distant water licensed boats do not operate significantly in this area. The three fisheries sectors differ in terms of resource management and fishing techniques and the relative importance of the three fisheries has changed considerably over recent decades. With the introduction of the 200-mile EEZs, Japan lost access to traditional long distance fishing grounds in many places around the globe. While distant water and offshore fisheries are characterised by high volumes, the offshore and coastal fisheries target high valued species for which there is a ready market demand. Japanese consumers are willing to pay high prices for freshness. Despite the reduced volumes in the coastal fisheries, the contribution by value is the highest of the three tuna fisheries (Sullivan 2013).

This investigation focuses on the Japanese coastal tuna fisheries. While Japan has contributed significantly to the collapse of the southern Bluefin tuna stock, Japan has been able to successfully manage several of its smaller, more localized fisheries in the western and central pacific , particularly the skipjack and albacore stocks. Yellowfin and bigeye stocks in the WCPA are not over fished but caution is advised (Harley et al. 2011). Coastal fisheries in Japana are co-managed by national and prefectural authorities along with organizations of local fishers called Fishery Cooperative Associations (FCA), based on a system of fishing rights. These Associations establish their own catch limits and no-take areas and govern the fisheries. While the federal government sets the Total Allowable Catch (TAC) for most fish, the FCAs decide on quota distribution and access rules, usually based on the recommendations of fisheries scientists (Makino 2011, Popescu and Ogushi 2013). At the centre of marine research in Japan is the Fisheries Research Agency (FRA), which conducts a wide range of research and development activities in fisheries, from basic research to practical applications and stock assessments.

One such smaller fishery, the Meiho fishery, has entered its pole-and-line skipjack and albacore tuna fishery for full assessment against the MSC Fisheries Standard for sustainable and well managed fisheries. The Meiho fishery is located in Shiogama, Miyagi Prefecture and catches average around 3000 tonnes of skipjack and albacore tuna per year. The fishery is managed both at the regional level through the Western Central Pacific Fisheries Commission (WCPFC,) as well as other regional bodies such as the Pacific Islands Forum Fisheries Agency (FFA) and Secretariat of the Pacific Community (SPC) and at national level through the Japanese Fisheries Agency, Ministry of Agriculture, Forestry and Fisheries (MSC 2015)

Very little is known about bycatch levels in the Japanese large pelagic fishery except as reported by FAO (1997) that bycatch consists mainly of blue sharks, oceanic white tips, makos, Walbeems sharpnose and other sharks. Tori lines and other seabird mitigation measures were pioneered by Japanese longline skippers to reduce bycatch of seabirds. However, scientific evaluations about the effectiveness of these mitigation measures are not well understood (Ochi et al. 2012). As of 2013 Japan had no ban on bycatch discards (Popescu and Ogushi 2013).

The USA, North Pacific albacore pole and troll fishery is undertaken off the US West Coast, between California and Washington, both within the US EEZ and well offshore in international waters. The fishery is MSC certified. Landings between 2001 and 2010 averaged around 11 928 tonnes pa (Bartoo et al. 2012). Trolling for albacore consists of towing artificial lures with barbless hooks, 'trolls', behind a fishing vessel at a speed of about 6 knots. If fishers see or feel a tuna on a line they pull it in. Trolling brings fish to the surface and helps to locate schools of albacore. The vessel stops near the school, and fishers keep the school close by throwing small amounts of live fish chum, often anchovy. In pole-and-line fishing, individual fishers use a stout pole, formerly constructed of bamboo and now made of fibreglass or a high-technology composite, with a short line that has a single barbless hook with either an artificial lure or live bait (MSC 2014). Trolling vessels will customarily operate with a skipper and one or sometimes two crew (Bartoo et al. 2012). Vessels commonly switch between gear types when conditions and catch rates dictate.

Albacore populations in the North Pacific are extensively monitored. Several government and non-governmental organisations together with members from the scientific community and the fishing industry contribute to the monitoring and study of albacore populations. International management of Pacific albacore is shared between the Inter American Tropical Tuna Commission and the Western and Central Pacific Ocean Fisheries Commission. Working groups of these Commissions conduct scientific stock assessments and co-ordinate research programs. Implementation of regulatory mechanisms occurs in the US through the Pacific Fishery Management Council, which has developed a Highly Migratory Species Fishery Management Plan (HMS FMP). Both Commissions have adopted a formalized precautionary approach to management. While specific precautionary control rules for albacore are in the process of being developed, the recent cap on effort for Northern albacore is a precautionary response to the scientific advice that the stock is approaching full exploitation (MSC 2009).

The most recent assessment of the North Pacific albacore stock was undertaken in 2011 for fishery data through 2009. It was estimated that the total stock biomass of North Pacific albacore was 800,000 tonnes in 2009, while the spawning stock biomass was near to the historic median of about 405,000 tonnes (WCPFC 2011 and Bartoo et al. 2012). The assessment inferred that overfishing of the North Pacific albacore stock is unlikely at present and that the current fishing mortality is less than, and in some cases much less than, commonly applied F-based target reference points. The 2012 MSC assessment recommended that the target reference point be set such that the stock is maintained at a level consistent with B_{MSY} or some measure or surrogate with similar intent or outcome and that well defined harvest control rules are in place that are consistent with the harvest strategy and ensure that the exploitation rate is reduced as limit reference points are approached (Bartoo et al. 2012).

Fishers may use one or both of these methods for harvesting. Both fishing methods are notably 'clean' methods that catch one fish at a time. Bycatch of non-target species is relatively rare and barbless hooks allow rapid and effective release of any bycatch species. No significant impacts on protected or endangered species have been identified. Discards are low, as fishers avoid schools of small sized fish due to lower prices. The most common species that are incidentally caught by the fishery include skipjack tuna (*Katsuwonus pelamis*), mahi mahi (Corypha*ena hippurus*), yellowtail (*Seriola lalandi*), Eastern Pacific bonito (*Sarda chiliensis*), Bigeye tuna (*Thunnus obesus),* and Bluefin tuna (*Thunnus thynnus*) (Bartoo et al. 2012). During the period 2002 to 2012 the maximum bycatch of any species or species group was 0.03% by weight of the albacore catch. These quantities are negligible and are considered to pose no risk to the stocks. Never the less, the PFMC maintains assessment and management oversight for the fisheries of tunas, billfishes and sharks undertaken in US waters (PFMC 2011b). Up until 2010 there was no systematic observer program, but the 2011 FMP has recommended that the pole and troll fishery is observed in future, with NMFS to develop and review the observer sampling plans (PFMC 2011a).

ETP species of potential relevance to the AAFA North Pacific albacore fishery include a variety of marine mammal, sea turtle and seabird species. However, interactions between ETP species and the AAFA pole and troll fishery are highly unlikely, given the very high selectivity of the gear. NOAA (2011) classified the North Pacific albacore pole and troll fisheries as a fishery with no marine mammal species or stocks killed or injured. There is a high degree of confidence that there are no significant detrimental effects (direct and indirect) of the fishery on ETP species.

The movement and near shore feeding behaviors of albacore are well understood. Contemporary catch, sea-surface temperature and chlorophyll data show that the distribution of albacore within the North Pacific Transition Zone (NPTZ) appears to be closely linked to the Transition Zone Chlorophyll Front, a permanent, sharp gradient in sea surface chlorophyll that shifts seasonally north and south through the NPTZ (Polovina et al. 2001), while in coastal regions their distribution is linked to coastal upwelling boundaries, with albacore being found on the oceanic side of the upwelling boundaries in warmer (>160C) and clearer (<0.3 mgm-3 chlorophyll) water (Laurs et al. 1984). Anchovy, saury, cephalopods and crustacean species are the most common prey items (Bartoo et al. 2012)

The pole-and-line fishery in the North Pacific uses anchovy for chum or bait (Bartoo et al. 2012). Anchovy catches are monitored. Currently the northern anchovy stocks experience limited targeted fishing pressure and relatively low levels of landings, and are not overfished or experiencing overfishing (PFMC 2010).

Traceability within the AAFA North Pacific albacore fishery is considered to be excellent. All albacore are landed as blast or brine frozen whole fish, no processing takes place at sea and although transhipment is permitted, this occurs very rarely if at all and with reporting required (Bartoo et al. 2012).

The Indonesian tuna long line and handline fishery is managed by the Western and Central Pacific Fisheries Commission (WCPFC). The WCPFC establishes management regulations that are implemented by member or cooperating non-member countries and territories. Indonesia became a member of the WCPFC in 2013. In addition to the WCPFC, the West Pacific East Asia Oceanic Fisheries Management Project was established between Indonesia, the Philippines, and Vietnam to improve the trans-boundary management and conservation of highly migratory fish like tuna (MMAF 2012a, c). Additionally, WWF and Sustainable Fisheries Partnership have also established fisheries improvement projects for the Indonesia tuna fisheries (WWF 2012, SFP 2013).

Indonesia is one of the largest tuna producing nations in the world and tuna is one of their primary export commodities. The total catch of tuna and tuna-like species in Indonesia has increased steadily since the early 1990’s. Indonesia exports fresh, frozen, and canned tuna to Japan, USA, European Union, Canada, China and Korea. In 2011, they exported 141,774 metric tons of tuna (MMAF 2012b). In Indonesia, tuna catches have increased substantially since 2000. Yellowfin tuna is the second most important tuna resource in Indonesia, behind skipjack tuna. In 2011, catches of yellowfin tuna by Indonesia were approximately 169,500 tonnes, with around 131,000 tonnes caught on the Pacific side (MMAF 2012a, b). The majority of the catches are taken in archipelagic waters or in Indonesia's Exclusive Economic Zone (EEZ), with very few catches made on the high seas/international waters. There are several tuna fisheries (differentiated by gear) in Indonesia. These include the purse seine, longline, pole and line, hand line, troll and gillnet fisheries. Indonesian surface longliners target both yellowfin and bigeye tuna. Yellowfin tuna is reported to account for 40-60% of the retained catch and bigeye tuna 10-20% of the catch. The coastal tuna fisheries are exploited by artisanal (trolling or hand line) and industrial (long line) tuna vessels. Artisanal fishing trips last 1 to 2 days and are restricted to coastal waters, while the industrial longliners operate for 1-3 weeks further offshore (Satria, 2011).

Management in Indonesia is currently poor, particularly with regard to the management of bycatch like sea turtles and sharks. The country is, however, working to improve the management of their tuna fisheries and the associated bycatch. The surface longline gear used to catch yellowfin tuna causes no damage to bottom habitats, but since tuna fisheries catch several top predator species, there is some concern that these fisheries may affect ocean food webs and ecosystems. Management only sometimes follows scientific advice (Davies et al. 2011, WCPFC 2012a, MBA 2013). Indonesia is still working on complying with all the required measures set by the Western and Central Pacific Fisheries Commission so enforcement and compliance levels are low. Indonesia has developed a National Tuna Management Plan that will address these issues (MMAF 2012b, c). Nevertheless management measures, through the help of the West Pacific / East Asia Fisheries Management Project (MMAF 2012c), have been sufficient to maintain sustainable abundance levels for some tuna and billfish species (e.g. yellowfin tuna, swordfish), but not for all species (e.g. bigeye tuna, sharks). Stakeholder participation in management is, however, well developed (BOI&MBA 2013).

At the regional level the status of the yellowfin tuna stock in the Western Central Pacific Ocean is well above B_{MSY} and fishing mortality is below F_{MSY} and is fully exploited. However, that portion of the stock in region 3 of the WCPFC area, which includes Indonesia is considered to be significantly overfished, with 65- to 70-percent depletion of total and adult biomass (WCPFC 2009). Meanwhile, in the Indian Ocean, the stock is likely currently in or approaching an overfished state and overfishing has likely been occurring in recent years (IOTC 2010). Bigeye tuna in the Western Central Pacific Ocean is understood to be approaching an overfished state if it is not already slightly overfished. Meanwhile, in the Indian Ocean, the stock size of and fishing pressure on bigeye tuna are close to optimal, indicating that the stock is fully exploited (IOTC 2010). Albacore in the Indian Ocean is considered to be well above the MSY level. Spawning stock biomass is considered to be at or very near to the SSB_{MSY} level (IOTC, 2012).

Indonesia has developed a National Plan of Action for Sharks, which aims to improve data collection, research, and management of sharks, but actual implementation of this plan remains limited (Satria et al. 2011). Bycatch in the longline and handline fisheries include swordfish and marlin (primarily black marlin) and these are retained (Widodo 2013). Other information from scientific observer studies on both the retained catch and discarded catch in tropical tuna longline fisheries in the western Pacific, suggests that silky shark, blue shark, shortfin mako, bigeye thresher, small-tooth thresher and oceanic whitetip sharks and blue marlin also make up a substantial proportion of the catch (Widodo 2013, Harley et al. 2011). Many of these shark species are threatened (Clarke 2011, BOI&MBA 2013). There are reports of interaction between sea turtles and the Indonesian tuna fisheries but there are no reports of interactions with seabirds.

Information on non-retained catch or discard species is not available for the Indonesia longline fishery. However, for shallow-water longline tuna fisheries in the tropical western Pacific, observer data indicates that target tunas (yellowfin/bigeye) account for 44% of the catch, silky sharks 15% of the catch, blue sharks 14%, blue marlin 8%, swordfish 5%, and other sharks and pelagic fishes the remainder (Harley et al. 2011). Discard rates for the shallow set longline fishery were estimated to be 2% for both yellowfin and bigeye tunas, 35% for silky sharks, 19% for blue sharks, 3% for blue marlin, and 13% for swordfish (SPC-OFP 2010). In general, the discard rate of sharks/rays was 49% and the discard rate of fish other than tunas/billfish was 54% (SPC-OFP 2010). Although estimates of dead discards were provided, fish released alive may still suffer mortality after being discarded (BOI &MBA 2013).

"Large pelagic" fisheries diagnostic

In all respects the MSC certified, USA albacore troll and pole fishery in the North Pacific is the stand-out fishery in comparison to the other three. It is in a better shape, is managed more effectively and the ecosystems impact mitigation measures are far superior in comparison to the other three tuna fisheries. It is no small wonder that the fishery is MSC certified. Moreover, the fishery also scores higher because the albacore stock is fully exploited in comparison to the other fisheries that are comprised of a combination of fully and over exploited stocks. The South African fishery is also well managed and from an ecosystems approach perspective is a very responsible fishery that adheres to and even exceeds international norms, particularly as this pertains to impact on seabirds. The reduction in seabird mortalities that has been achieved by implementing a well-designed strategy has been remarkable and other tuna fisheries can learn from this. According to the scoring system adopted here the SA fishery takes second place, followed by the Japanese coastal tuna fishery. The Indonesian fishery lags behind the other three, mainly because of higher bycatch discard levels, political interference in management decisions, non-optimal management measures and low compliance levels. Although it is evident that Indonesia is doing all it can to improve its multi-faceted tuna fishery, management of this fishery is complex and much still needs to be achieved for it to be operate under best management practices.

Table 9. Composite scoring table for the RSA tuna longline and pole fishery, the USA albacore pole and troll fishery, the Japanese coastal tuna fishery and the Indonesian tuna fisheries.

		Points	RSA Tuna	Japan Tuna	USA Tuna	Indonesia Tuna
A	**Stock status** **MAX**	**10**	LL&P	LL&P	T&P	LL&HL
A1	Non-fully exploited (B>60% of pristine,CPUE>60% of initial rate,SSB>40% of unfished B)	**10**				
A2	Fully exploited (B=40-60% of pristine, CPUE = 40-60% of initial rate, SSB=20-40% of initial)	**8**			8	
A3	Stock status unknown but resource managed on a sustainable basis	**7**				
A4	Multi species fishery with under, fully and over exploited stocks	**6**	6	6		6
A5	Over exploited (B<40% of pristine, SSB<20% of unfished B, but showing signs of recovery)	**4**				
A6	Over exploited (same as above but B, SSB, CPUE and size composition trends decreasing)	**1**				
B	**Ecosystem impact mitigation** **MAX**	**20**				
B1a	Low habitat impact	**3**	3	3	3	3
B1b	Medium habitat impact	**2**				
B1c	High habitat impact	**1**				
B2a	Habitat impact mitigation measures implemented or not required	**2**	2	2	2	2
B2b	No habitat impact mitigation measures implemented	**1**				
B3a	Bycatch <5% of catch	**3**			3	
B3b	Bycatch <10% of catch	**2**		2		
B3c	Bycatch >10% of catch	**1**	1			1
B4b	Impact on ETP species understood / studied and mitigation measures implemented	**2**	2	2	2	
B4c	Impact on ETP species not well understood and no mitigation measures implemented	**0**				0
B5a	Voluntary habitat/ecosystem impact mitigation measures implemented	**3**			3	
B5b	No voluntary habitat/ecosystem impact mitigation measures implemented	**1**	1	1		1
B6a	By catch management plan in place	**2**	2		2	
B6b	No by catch management plan	**0**		0		0
B7a	Fish bycatch mitigation measures implemented	**2**	2	2	2	2
B7b	No fish bycatch mitigation measures implemented	**0**				
B8a	Fish bycatch mainly retained	**3**	3			
B8b	Fish bycatch partially retained/discarded	**2**		2	2	2
B8c	Fish bycatch mainly discarded	**1**				
C	**Effective Management** **MAX**	**20**				
C1a	Regular (annual or biennial) assessments of B, SSB and F or other	**3**				
C1b	Irregular assessments B, SSB and F or other	**2**	2	2	2	2
C1c	No assessments	**0**				
C2a	Science based management plan in place in accordance with the precautionary principle	**2**	2	2	2	
C2b	Major differences between scientific advice and management plans	**0**				0
C3a	Ecosystems approach to management applied or actively researched	**2**	2	2	2	
C3b	Ecosystems approach to management neither applied nor researched	**0**				0
C4a	Best management methods employed (TAC,TAE,ITQs, Closed seasons / areas)	**2**	2	2	2	
C4b	Non optimal management measures employed	**1**				1
C5a	Industry actively involved in the management of the resource	**2**	2	2	2	2
C5b	Industry not actively involved in the management of the resource	**0**				
C6a	Fishers compliant (Catch vs TAC, over or under reporting of catches)	**2**	2		2	
C6b	Fishers not very compliant	**1**		1		1
C7a	Strong MCS measures employed	**2**			2	
C7b	Weak MCS measures employed	**1**	1	1		
C7c	No MCS measures employed	**0**				0
C8a	Sea based observer programme in force (ALL Vessels Full Time)	**3**				
C8b	Sea based observer programme in force (SOME Vessels Full Time	**2**	2			
C8c	Sea based observer programme in force (SOME Vessels Occasionally)	**1**		1		1
C8d	No sea based observer programme	**0**			0	
C9a	Landbased inspection programme in force (ALL landings)	**2**	2		2	
C9b	Landbased inspection programme in force (SOME landings)	**1**		1		1
C9c	No landbased inspection programme in force	**0**				

4. The rock lobster fisheries

This study benchmarks the South African south coast and the west coast rock lobster fisheries against the Western Australian, the Mexican Baja California and the Brazilian rock lobster fisheries. Two of the fisheries, the Western Australian as well as the Baja California fisheries are MSC certified and as will be shown, both are extremely well managed and highly sustainable. The comparative scores of the five fisheries are shown in Figure 9 and the actual scores per assessment criterion are shown in Table 10. Table 11 presents the scores for all indicators.

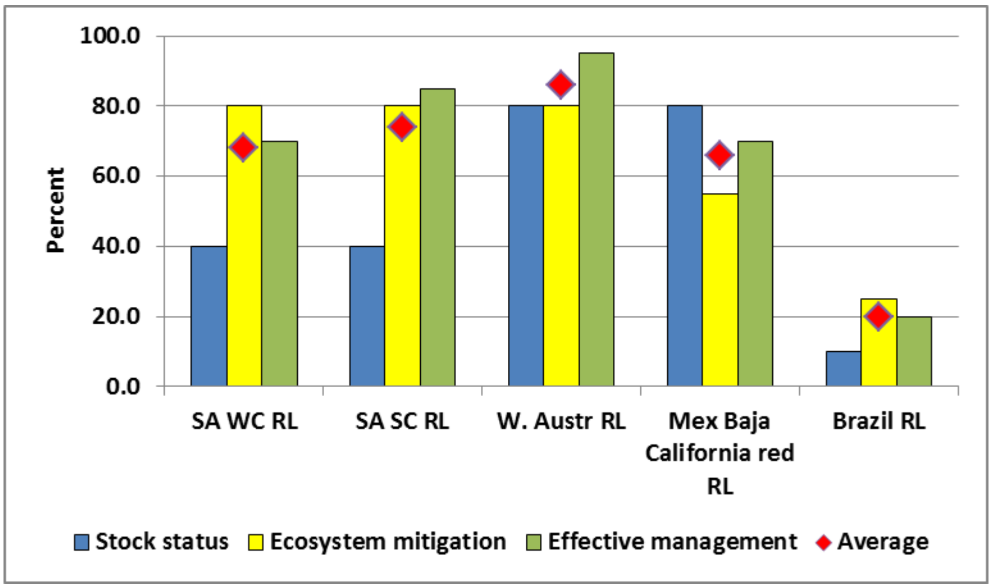

Figure 9. Benchmark criteria and average percent score for the five rock lobster fisheries.

Table 10. Benchmark criterion points for the five rock lobster fisheries.

POINTS	RSA West Coast RL	RSA South Coast RL	Western Australia RL	Baja California red RL	Brazil RL
Stock status (10)	4	4	8	8	1
Ecosystem mitigation (20)	16	16	16	11	5
Effective Management (20)	14	17	19	14	4
Total score (50)	34	37	43	33	10
Average	11.3	12.3	14.3	11.0	3.3
MSC certified	No	No	Yes	Yes	No
Ranking on average score	4	2	1	3	5

The South African south coast rock lobster fishery targets *Palinurus gilchristi, which* is endemic to the south and south east coast of South Africa, where they occur between 50 and 350m. The fishery operates between East London and Cape Point and up to 250 km offshore, along the outer edge of the Agulhas Bank. Fishing gear is restricted to long lines with traps and it is the second largest rock lobster fishery in South Africa (Pollock and Augustyn 1982, Groeneveld 2003). The fishery started in the mid 1970s and is capital-intensive, requiring specialized equipment and large oceangoing vessels.

The South Coast rock lobster (SCRL) fishery is managed by a combination of output and input controls. The output control is a Total Allowable Catch (TAC) and IQs (Individual Quotas) and the input control is a Total Allowable Effort (TAE), which is a limitation on the number of fishing days per season. The TAC is the primary control measure. The TAE, based on a fishing day allocation, is a secondary measure (Berg 2014). The TAC limits the total catch and is based on an annual resource assessment, whereas the TAE is measured in fishing days allocated to each vessel. A vessel may fish until its fishing days expire or its quota is filled, whichever occurs first (DAFF, 2012). The scientific recommendations for catch limits are based on an OMP, which was introduced in 2008 and modified in 2010. The objectives of the OMP are to keep the inter-annual TAC change restricted to 5% and to increase the spawning biomass of the resource by 20% over the next 20 years (DAFF, 2012).

Resource assessments introduced in 1993–1994 indicated that an annual catch of 477 tonnes (tail mass) could not be sustained. Consequently, a programme of annual TAC reductions was initiated in 1994–1995, reducing the TAC in steps of 25 tonnes per year. In spite of the reduction, the 2001 assessment of the resource indicated that the reductions had failed to impact significantly on the trend of declining abundance. The 2001 CPUE-index indicated that the abundance of this resource had declined by 65% over the 12 years between 1988 and 2000 (DAFF, 2012).

An age-structured production model is used to assess the South Coast rock lobster stock on an annual basis. A tagging programme supplied the critical growth and population size estimates as well as estimates of migration. Commercial CPUE data are captured from landing slips. These provide input data for TAC and TAE calculations. The exploitable biomass is currently around 27% of pristine. Spawner biomass is around 31% of pristine and maximum sustainable yield is approximately 359–440 tonnes of tail mass. The TAC declined from 382 tonnes in 2007–2008 to 345 tonnes in 2009–2010. The reasons for the decrease are the slight net downward trend in CPUE over the past five years. During 2014 the OMP for the resource was reinvestigated and re-revised. Stock assessment results tabled at that time indicated that the resource was in a healthy state with an overall spawning biomass in excess of 35% of pristine (Bergh 2014).

There is active collaboration between the DAFF and the South Coast Rock Lobster Industry Association to understand the spatial and temporal distribution of berried females throughout the known distribution range and to investigate the possibility for the introduction of a fishery-independent survey (FIMS) for this resource. Moreover, there is an active ecosystems based research program on the resource.

The number of days spent at sea by each vessel is monitored. Catches may only be off-loaded in the presence of a Marine Control Officer and the catches are weighed at designated offloading harbours. Skippers must, at the conclusion of each trip, provide DAFF with accurate daily catch statistics. Scientific observers were deployed aboard commercial South Coast rock lobster fishing vessels, but the national observer programme was terminated in 2011.

The SA west coast rock lobster fishery is the largest lobster fishery in the country and fishing gear include hoop nets, traps, pots and recreational diving. The stock is severely depleted and is only at 3 per cent of its pre-exploitation levels and is further threatened by rampant poaching. The fishery has been managed on the basis of a TAC. By 2003, the resource had improved to 16% above the 1996 level. However, by 2006 resource abundance had decreased dramatically due to recruitment failure and increased fishing pressure (an increase in the number of near shore right-holders). The commercial TAC was decreased by 10% for the following three consecutive seasons (2006/2007, 2007/2008 and 2008/2009) in an attempt to rebuild the stock to the new target of 20% above 2006 levels by 2016. For 2011/2012 the global TAC was 2425.78 tonnes. If current catch rates are maintained, the stock should continue to rebuild (WWF 2013).

Since 2011 the resource has been managed by way of an OMP (DAFF 2012), valid for 4 years at a time (Johnston et al. 2011). The TAC is set annually and is subdivided across the geographical lobster areas. The key annual inputs into the OMP are: the commercial CPUE for both hoop net and trap fishing, the Fisheries Independent Monitoring Survey (FIMS) index, and the somatic growth rates (Bergh 2014). The DAFF organises a panel of international experts that meets annually to review the OMP. The 2012/13 TAC was not set in accordance with the recovery targets and the scientific recommendations, raising concerns about the future management and sustainability of this stock (WWF 2013).

Current biomass is at approximately 3.2% of pristine biomass. The management objective is to increase the male biomass (of commercially sized rock lobsters) by 35% of its current levels by 2021 relative to the 2006 level (Johnston et al., 2011). There is a considerable amount of poaching from the stock. This increases uncertainty of the stock assessment. The fishery is managed on the basis of a TAC, TAE, seasonal closures, minimum carapace size and a ban on landing berried females.

All fishing methods are very selective, and thus bycatch levels are low. Furthermore, the fishing methods are minimally destructive to benthic habitats or benthic species, but depletion of lobsters will have had effects on the benthos as WCRL has important effects as a predator. Other issues of concern are whale entanglements in the gear as well as gear loss, which results in ghost fishing (although data from the Baja California fishery show that ghost fishing by traps is negligible). However, the netting for the traps is now made of bio-degradable materials and obviates the concern (WWF 2013).

The commercial fishery for West Coast rock lobster is controlled by company-allocated quotas within a total allowable catch (TAC), subdivided by geographical area (DAFF 2011a and b). Catches are monitored at landing sites by compliance officers. Bycatch levels are <5% and survival of all returned animals is >75%. There is circumstantial evidence that fishing results in substantial ecosystem changes (WWF 2013). Indications are that compliance levels are low and that a greater degree of transparency with respect to management be instituted and currently there is no observer programme (WWF 2013). An ecosystems based management plan is being implemented and the first ecological risk assessment was conducted in 2005 (Nel et al. 2007, Petersen et al. 2010).

The Western Australian (WA) rock lobster, *Panulirus cygnus*, is the target of WA's largest and most valuable fishery, worth about AU$200– 400 million annually. The fishery for western rock lobster is a low impact "potting" fishery and occurs in inshore regions in shallow waters to the outer edge of the continental shelf (200 m depth). The western rock lobster is caught throughout its geographic range and provides the basis of the economies of a number of coastal towns, as well as supporting a recreational fishery (de Lestang et al. 2012). The recreational fishery issues about 45 000 licenses annually and accounts for about 3% to 4% of the total catch. The commercial catch for 2012/2013 season was 5641 tonnes and 128 tonnes for the recreational fishery (de Lestang et al. 2014).

The Western Australian rock lobster fishery was the first fishery in the world to receive MSC certification in 2000 and was recertified in 2006 and in 2012. Governance of the fishery is a joint effort involving Department of Fisheries and the Western Australian Fishing Industry Council in consultation with the Western Rock Lobster Council (WRLC) and Recfishwest provides advice on the management of the recreational fishery . Management of the fishery is based on maintaining acceptable levels of zone-specific SSB, relative to their threshold Biological Reference Points, which are designed to ensure that the egg production in each zone of the fishery remains above its threshold level and that the probability of being above this level in five years is at least 75% (Department of Fisheries, 2012). SSB estimates are well above the management threshold levels and in 2012 the breeding stock was at the highest level in 20 years. The fishery has recently changed from a total allowable effort (TAE) system, based on a set of input controls, to an output-based management system that uses catch limits. It was scheduled to move to an Individual Transferable Quota (ITQ) based management system in 2013, while retaining some necessary input controls (Department of Fisheries, 2012).

A crucial element in predicting catches is the annual assessment of abundance of pueruli settling on inshore reefs along the west coast between August and January. This is known as the Puerulus Settlement Index (PSI) and has always shown a strong correlation with catches of lobsters three or four years later. The fishery has received international acknowledgement as one of the best managed and most sustainable fisheries in the world. The annual assessment programme also provides estimates of spawner biomass levels, as well as information on natural variations in the fishery, as it responds to both fishing and environmental conditions. Environmental factors such as the strength of the Leeuwin current, winter and spring westerly winds and water temperatures, play an important role in determining the survival and settlement of larval lobsters (de Lestang et al. 2012). Recruitment has been below average in the fishery in recent years, and has meant a significant reduction in the volume of lobster taken from the fishery – a reduction of almost half from the 2005/06 catch – to ensure the sustainability of the stocks.

The fishery has strict management measures in place including seasonal closures, minimum size requirements and a ban on catching breeding females. Commercial fishers, processors and the Western Australian government work closely together to preserve the fishery's future.

A consequence of the introduction of these quota management measures has been a significant reduction in the number of pots being used in the fishery, which in turn has significantly reduced the fishery's impact on the surrounding ecosystem. The impact of the fishery on the environment and ETP species is well understood and mitigation measures are implemented. The highest risk is of sea lion pups and leather back turtles becoming entangled with pot lines and the contact of pots with corals resulting in potential changes to coral abundance. The industry has now enforced the implementation of Sea Lion Exclusion Devices to minimise the mortality of sea lions and has banned the use of bait bands that can entangle marine mammals (MSC 2012).

The Mexico Baja California Red rock lobster (*Panulirus interruptus*) fishery is a small (10 cooperatives) community based fishery, with an annual catch of around 1300 tonnes per annum. It was recently re-certified by the MSC (SCS 2011). The California Spiny Lobster (*Panulirus interruptus*) is a temperate to subtropical species, distributed from Southern California (USA) south to the Baja California Peninsula tip in Mexico and it occurs in rocky areas from the intertidal zone to depths of around 100m (SCS 2011). The Mexican fishery is located in Central Baja California, Mexico. This area extends from Cedros Island in Baja California through Punta Abreojos in Baja California Sur and includes Isla Guadalupe approximately 250 km off the coast of Baja California, Mexico. The fishery is a model for successful collaboration between government, fishermen and conservation organisations. The 10 participating cooperatives are part of the Federación Regional de Sociedades Cooperativas de la Industria Pesquera Baja California (FEDECOOP). Together they operate 232 vessels and use approximately 15,635 traps each season to harvest the lobster. Each cooperatives fishes an exclusive area under a long-term concession (or license) granted by the government. Unusually, each has its own biologist or technician to assist with data collection and to provide scientific advice. Areas can be closed if there are concerns about stock, there is a minimum legal size for lobsters, females with eggs cannot be taken and only certain gear types are permitted. All traps must be fitted with escape gaps so under-size lobsters do not get caught. The fishery is managed by the Federal Government of Mexico through the regulatory agency Comisión Nacional de Acuacultura y Pesca.

There are three main management measures of the fishery and these are;

1) Limited access rights. Access rights are subject to concessions or permits, which define limitations on fishing areas and limit the number of boats and traps being proposed by the fishing coops in their mandatory annual programs;

2) Regulatory measures to protect reproduction and recruitment, such as minimum sizes, spatial and temporal closures, protection of berried females and escape windows in traps, and

3) Mechanisms for co-management, which facilitate the coordination between fishers and technical personnel of the Instituto Nacional de la Pesca (INAPESCA) starting from the collection of data to discussions of research results, during which recommendations for management are openly and transparently discussed before their submission to the fisheries authorities (SCS 2011).

In the latest MSC assessment in 2011 (SCS 2011) the fishery scored 80% or more on each of the three MSC principles, although 5 indicators were below the compliance mark and these were “assessment of stock status”, all three bycatch indicators, and ecosystems information.

INAPESCA has been assessing the stock regularly for the last 14 years using various models, including a modified version of the Biomass Dynamic Model that incorporated environmental variability through the use of sea surface temperature anomalies, using the 1971-72 to 1996-97 catch and effort time series. Vega et al. (2003 in SCS2011) also used a model with Lagged Recruitment, Survival and Growth (LRSG), which is a more flexible model that incorporates alternative life history characteristics. The LRSG model was found to be appropriate for the California red lobster because recruitment events of a particular year for this species have been correlated with the catch 5 years later (SCS 2011). In 2000 INAPESCA decided to set reference points at MSY (incorporating biomass, fishing mortality, effort and rate of exploitation) using the Biomass Dynamic Model, particularly for B_{MSY} and that management decisions would be taken depending on the relationship of current biomass (B) with the B_{MSY} by looking at the ratio of one to the other (B/ BMSY). If the value of the ratio of B/ B_{MSY} is <1 then the stock will be considered under its optimum level, while a fishery with a ratio value >1 will be considered over its optimum, or if $B/ B_{MSY} =1$ then the fishery will be at optimum level (SCS 2011). The 2003 and 2006 assessments used a modified Leslie-Delury model, a length based Virtual Populations Analysis and a Thompson and Bell production model (Vega, 2006). In the latest analysis, Vega et al. (2010 in SCS 2011) used only the Hilborn and Walters Biomass Dynamic Model using the seasonal catch and effort time series from 1960 to 2010. They found that the biomass was 1.5 x higher than B_{MSY}.

The latest stock assessment (Vega et al. 2010 in SCS 2011) found that Fishing Mortality (F) was 0.10, which is half F_{MSY} (0.20). Effort (f), was 2,218,377 trap-hauls, which was equivalent to 38% of the F_{MSY} (5,785,700 trap-hauls). Although the biomass, catch and effort values were within the MSY parameters it was never the less recommended that effort should not be increased for economic reasons (Vega et al. 2010 in SCS 2011).

The lobsters are caught using traps. The traps are rectangular and covered with galvanized, plastic-sheathed wire mesh and operated from small (5-7m) outboard powered boats. Traps are baited with fish or molluscs. Traps are fitted with escape gaps. These are gaps in the sides of the trap to allow small lobster, less than legal size, to escape. The fishery was first MSC certified in 2004 and recertified in 2011.

Due to the high value of the lobster fishery, and in order to conserve the resource, the cooperatives developed a highly efficient inspection and surveillance system inside their fishing area to eliminate illegal fishing. The Surveillance Committee also participates in the enforcement of the legal minimal size by double checking catch with the Quality Control group of the Cooperatives during the landing process. In the case of deception by a fisher member, economic sanctions or fishing activity suspensions could be applied including the potential exclusion of membership from the cooperative. This ensures a very high level of compliance. Several monitoring programs are also carried out by the cooperatives: 1) a monitoring program to record monthly catch and effort information; 2) a monthly sampling program of the size and sex structure of all catches from one fishing vessel during the season; 3) a monthly sampling program for the size and sex structure of a proportion of all commercial catches; and 4) a monitoring program that analyzes the reproductive stages of lobster during the closed season. Market prices are monitored during the fishing season in order to evaluate the economic feasibility and to assess the production costs against the potential earnings. These data are used to decide on early closure of the season to avoid poor economic gains (SCS 2011).

Harvesting control rules are applied by each cooperative based on the results of the latest fishing season and fishing effort (number of boats and traps) for the following season is controlled to maintain current biomass above B_{MSY}. Biomass levels from the 2006-2010 assessments indicate that biomass has been kept at an optimal level or above. This provides evidence that harvest control rules have been effective (SCS 2011).

It has been recommended that a model or models that better incorporate biological data and that account for uncertainty and allow for the estimation of confidence intervals be developed and applied (SCS 2011).

Shester (2008) found that the total incidental bycatch was approximately 13% of landed lobster catch by weight. The main non-target bycatch in lobster traps were other crabs, octopus and gastropods and 4 species of bony fish and some small sharks and rays. Shester (2008) noted that the due to their pivotal role as top predators in the ecosystem, the most ecologically significant non-retained bycatch in this fishery are cormorants (*Phalacrocorax* spp.). There are no records of interactions with ETP species. Approximately 4000 to 5000 tonnes of baitfish are used annually of which 1/3 may be caught locally and is taken from unmanaged fish stocks.

As with all trap fisheries the impact on the environment and the substratum is low and levels of ghost fishing are between 1-2% of the total annual catch (Shester 2008).

The Brazilian rock lobster fishery harvests two species, *Panulirus argus* (red lobster) and *Panulirus laevicauda* (green lobster). Lobster are exported mainly to the US market, with an average value of USD 60 million per year and provides a livelihood to more than 15 000 fishermen. However, the fishery is now close to collapse, due largely to uncontrolled fishing, poor management and poor enforcement. Since 2002, the Brazilian government has been attempting to change management practices in this fishery, with limited success. However, since about 2010 the situation has become rather chaotic with illegal divers fueling the "lobster war". It has been estimated that over 90% of exported lobster now originates from illegal fishing (Braga et al. 2012).

Key issues (Sustainable Fisheries Partnership 2014) in the Brazilian lobster fishery are:

- No stock assessments have been performed since 2006 with the last one showing that the stock is overfished.
- Neither adequate limit nor adequate target biological reference points have been set.
- A harvest strategy exists, but monitoring has been deficient since 2006.
- Existing rules about effort limits are not realistic because they are established as "trap equivalent" quantities and there is no calculation for these equivalences for gillnets and diving, which are largely used instead of traps.

- There is a lack of information about the impacts of the fishery on ETP species, bycatch and the seabed.
- The legal framework is generally acceptable but lacks specific goals and clear instruments.
- The Lobster Management Commission (CGPL) has not been effective since 2004.
- The decision-making process at CGPL, though participatory, is not responsive and is not publicly documented.
- No incentives for sustainable practices are currently in place.
- No research plan is currently in place.

Although stricter regulations have been recently implemented, management is still considered ineffective due to lack of enforcement and compliance with regulations. A management plan was developed in 2008, although it has not yet been implemented. Annual stock assessments are not undertaken, limit and target reference points, as well as harvest controls such as total allowable catch and community quotas are not being set. According to the latest available data (2006), the spiny lobster in Brazil is “overfished” and exploitation levels might not be sustainable in the long term (FAO 2006).

Although the fishery is officially a pot fishery, gillnets although prohibited, are still used in some parts of the Brazilian rock lobster fishery. Gillnets have considerable bycatch including turtles and fish species. Gillnet fishing for spiny lobster also negatively impacts the sea bed habitat, in particular sea grass, calcareous algae and coral reef habitats (Sustainable Fisheries Partnership 2014).

Rock lobster diagnostic

The Western Australian rock lobster fishery was ranked in first place, followed by the RSA south coast rock lobster fishery. Ranked third and fourth were the SA west coast rock lobster and the Baja California rock lobster fisheries (although the scores were almost identical). The Brazil rock lobster fishery was ranked last. In all respects, the Western Australia rock lobster fishery stands out as the model rock lobster fishery. The stock is in a healthy state, the science underlying management is of the highest order, the fishery is strictly controlled and co-managed with a high level of compliance and the environmental impacts are low. Despite the current poor state of the SA rock lobster stocks, the high scores attained by the fisheries are a consequence of the ecosystems based science that supports management, the ecosystems mitigation measures that are in place, e.g. bycatch management plan, low impacts on environment and ETP species, and the effective management systems and compliance levels in the east coast rock lobster fishery. Poor compliance in the SA west coast rock lobster fishery and the high level of poaching dragged this fishery into 4th place. The Mexican Baja California fishery is characterized by the health of the stock and the very high level of involvement in management by the 10 cooperatives that participate in the fishery and the resultant high levels of compliance, but it does not fare very well on the scientific front. The Brazilian fishery seems to be in a chaotic state and according to available information seems to be mainly an illegal fishery at this stage, characterized by extreme levels of poaching. It should be noted that political interference in the setting of the 2012/13 TAC for the SA west coast rock lobster fishery was treated as a singular event, which will hopefully never occur again.

The fishery is also plagued by poaching and if this is not curtailed by the authorities then the fishery may very well collapse in future, or become a free for all.

Table 11. Composite scoring table for the RSA south and west coast rock lobster fisheries, the Western Australian fishery, and the Mexican Baja California and the Brazilian rock lobster fisheries.

		Points	RSA	RSA	West	Mexico Baja	
A	**Stock status** **MAX**	**10**	WC RL	SC RL	Australia RL	California RL	Brazil RL
A1	Non-fully exploited (B>60% of pristine,CPUE>60% of initial rate,SSB>40% of unfished B)	**10**					
A2	Fully exploited (B=40-60% of pristine, CPUE = 40-60% of initial rate, SSB=20-40% of initial)	**8**			8	8	
A3	Stock status unknown but resource managed on a sustainable basis	**7**					
A4	Multi species fishery with under, fully and over exploited stocks	**6**					
A5	Over exploited (B<40% of pristine, SSB<20% of unfished B, but showing signs of recovery)	**4**	4	4			
A6	Over exploited (same as above but B, SSB, CPUE and size composition trends decreasing)	**1**					1
B	**Ecosystem impact mitigation** **MAX**	**20**					
B1a	Low habitat impact	**3**		3	3	3	
B1b	Medium habitat impact	**2**	2				
B1c	High habitat impact	**1**					1
B2a	Habitat impact mitigation measures implemented or not required	**2**	2	2	2	2	
B2b	No habitat impact mitigation measures implemented	**1**					1
B3a	Bycatch <5% of catch	**3**	3				
B3b	Bycatch <10% of catch	**2**		2	2		
B3c	Bycatch >10% of catch	**1**				1	1
B4b	Impact on ETP species understood / studied and mitigation measures implemented	**2**	2	2	2		
B4c	Impact on ETP species not well understood and no mitigation measures implemented	**0**				0	0
B5a	Voluntary habitat/ecosystem impact mitigation measures implemented	**3**				3	
B5b	No voluntary habitat/ecosystem impact mitigation measures implemented	**1**	1	1	1		1
B6a	By catch management plan in place	**2**	2	2	2		
B6b	No by catch management plan	**0**				0	0
B7a	Fish bycatch mitigation measures implemented	**2**	2	2	2		
B7b	No fish bycatch mitigation measures implemented	**0**				0	0
B8a	Fish bycatch mainly retained	**3**					
B8b	Fish bycatch partially retained/discarded	**2**	2	2	2	2	
B8c	Fish bycatch mainly discarded	**1**					1
C	**Effective Management** **MAX**	**20**					
C1a	Regular (annual or biennial) assessments of B, SSB and F or other	**3**	3	3	3		
C1b	Irregular assessments B, SSB and F or other	**2**				2	
C1c	No assessments	**0**					0
C2a	Science based management plan in place in accordance with the precautionary principle	**2**	2	2	2	2	
C2b	Major differences between scientific advice and management plans	**0**					0
C3a	Ecosystems approach to management applied or actively researched	**2**	2	2	2		
C3b	Ecosystems approach to management neither applied nor researched	**0**				0	0
C4a	Best management methods employed (TAC,TAE,ITQs, Closed seasons / areas)	**2**	2	2	2	2	
C4b	Non optimal management measures employed	**1**					1
C5a	Industry actively involved in the management of the resource	**2**	2	2	2	2	
C5b	Industry not actively involved in the management of the resource	**0**					0
C6a	Fishers compliant (Catch vs TAC, over or under reporting of catches)	**2**		2	2	2	
C6b	Fishers not very compliant	**1**	1				1
C7a	Strong MCS measures employed	**2**			2	2	
C7b	Weak MCS measures employed	**1**	1	1			1
C7c	No MCS measures employed	**0**					
C8a	Sea based observer programme in force (ALL Vessels Full Time)	**3**					
C8b	Sea based observer programme in force (SOME Vessels Full Time	**2**			2		
C8c	Sea based observer programme in force (SOME Vessels Occasionally)	**1**		1			
C8d	No sea based observer programme	**0**	0			0	0
C9a	Landbased inspection programme in force (ALL landings)	**2**		2	2	2	
C9b	Landbased inspection programme in force (SOME landings)	**1**	1				1
C9c	No landbased inspection programme in force	**0**					

5. The squid fisheries

The South African chocka fishery was benchmarked against the Peruvian jumbo flying squid fishery, the California market squid fishery and the Argentine shortfin squid fishery. It should be noted that for squid the scoring system for bycatch retention was changed, such that the release of bycatch obtains the highest score while in all other fisheries the retention of fish bycatch has the highest score. The percent scores of the four fisheries are shown in Figure 10 and the actual scores per assessment category are shown in Table 12, while Table 13 shows the scores for all indicators.

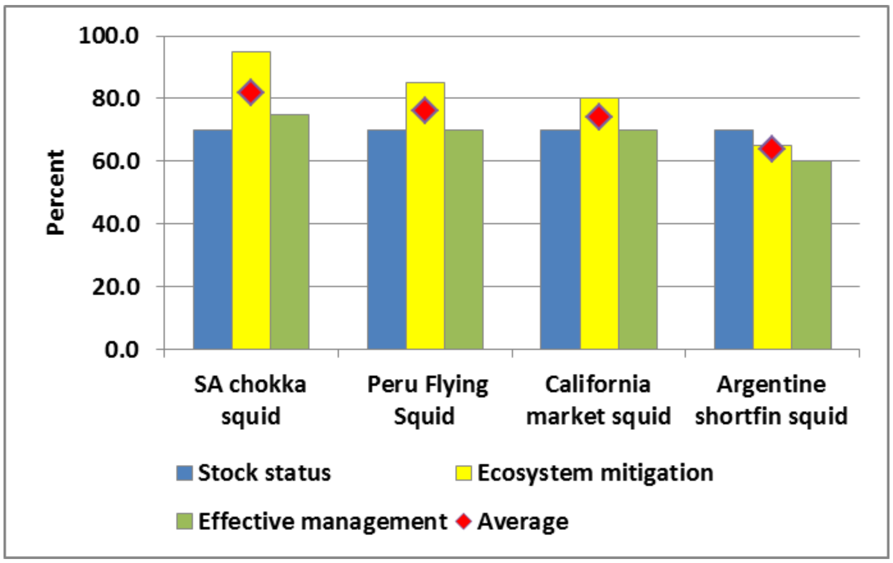

Figure 10. Benchmark criteria and average percent score for the four squid fisheries.

Table 12. Benchmark criterion points for the four squid fisheries.

POINTS	RSA chokka squid	Peru jumbo flying squid	California market squid	Argentine shortfin squid
Stock status (10)	7	7	7	7
Ecosystem mitigation (20)	19	17	16	13
Effective Management (20)	15	14	14	12
Total score (50)	41	38	37	32
Average	13.7	12.7	12.3	10.7
MSC certified	No	No	No	No
Ranking on average score	1	2	3	4

The South African squid (*Loligo vulgaris reynaudi*) resource is exploited by two fisheries: the jig fishery and the demersal inshore trawl fishery, in which squid are caught as a bycatch (Glazer & Butterworth, 2006). The fish are caught using hand lines (up to 3 per fisherman) with two jigs (also known as dollies) per line. At night all vessels use lights to attract the squid. Most of the catch from the jig fishery is exported, freshly frozen, to European markets and some is used for bait in the local recreational fisheries. The abundance of squid fluctuates widely, owing to biological events such as spawning distribution, survival rates and environmental factors such as temperature, currents and turbidity, as well as environmental events such as El Niños. In 2004 the jig fishery registered its highest catch of over 12 000 tonnes . Catches in the 1990s ranged between 2 000 and 7 000 tonnes, and in the 2000s between 3 000 and 13 000 tonnes (DAFF 2012).

The fishery is effort controlled and is capped at a maximum TAE of 2 422 crew or 136 vessels. In addition, a five week closed season is implemented annually and this is now supplemented with additional voluntary closed seasons with the intention of protecting spawning squid and improving recruitment in the following year. The current management objective for the fishery is to cap effort at a level that secures the greatest catch, on average, in the longest term, without reducing the resource to levels at which future recruitment success may be impaired or catches drop below economically viable levels (DAFF, 2012).

The first formal stock assessment was conducted in 1998. Results from the model indicated that the resource was at a high risk (~90%) of collapsing at the level of effort at that time of around 3.6 million man-hours. Risk was defined as the probability of the spawner biomass dropping below 20% of carrying capacity at least once within a 10 year projection period under a fixed level of effort. It was estimated that a 33% reduction in effort was required in order to reduce the risk to a more acceptable level of approximately 20% but, because of concerns about the social implications and industry stability only a 10% reduction in effort was selected for implementation. This had an associated risk of 72%. Subsequently, the model of Roel et al. (1998) was refined by Glazer and Butterworth (2006) who used a Bayesian estimation approach. The most recent update of this model, incorporating data to 2008, indicated that the squid resource was in a healthier condition than previously estimated, largely due to several successive years of above-average recruitment. Despite this, there is concern that latent effort exists in the fishery. Verification of this is currently underway and, until some resolution has been obtained and pending an updated and more reliable assessment, the TAE has been maintained at a constant level for the past 8 years (Cochrane et al. 2014, Bergh 2014).

Hand jigging is a highly selective fishing method, which has little to no impact on the marine environment. Occasionally (but very rarely) shortnose spiny dogfish (*Squalus megalops*), mackerel (*Scomber japonicus*) and hake (*Merluccius capensis*) are hooked but these are released alive. The impact on ETP species is zero. However there is some impact on the benthic habitat as well as on squid eggs from anchors and anchor chains. The hand jigging fleet may not land any fish other than squid. The impact of the light used by the fishery on other associated fauna is not well understood.

There is full compliance with the closed season(s), the ban on landing any bycatch as well as with the number of allocated fishers per vessel and the prohibition of fishing in MPAs.

The Peruvian jumbo flying squid, *Dosidicus gigas*, is widely distributed in the eastern Pacific Ocean from California to southern Chile (Nigmatullin et al., 2001). In Peru, the fishing activity for squid or "pota" is exerted mainly by industrial Japanese and Korean, automated squid jigging vessels, with a holding capacity of 300 to 1 000 tonnes, which have been fishing off Peru since 1991. The jumbo flying squid represents the most important pelagic invertebrate fishery in Peru (Liu et al. 2010).

The fishery is managed by quotas, in tonnes per boat, and per the total fleet and this is awarded by tender. To date, the most important management restriction is the establishment of a protection zone of 30 nautical miles adjacent to the Peruvian coast (Liu et al. 2010).

Assessments of jumbo flying squid are based on acoustic surveys conducted by the Marine Research Institute of Peru (IMARPE). Since jumbo flying squid is an annual species, the population is assessed at the beginning of the season and probable catches are estimated so that the recommended TAC ensures that 20% of the population (as assessed at the beginning of the season) remains in the water for reproduction (escapement criterion). In spring (September), an assessment of the intensity of spawning is conducted and preliminary recommendations are issued regarding the TAC for the first half of the following year. Managers set TACs follow scientific advice. In 2012, a TAC of 500,000 tonnes was set for jumbo flying squid, which was in line with the TAC advised by IMARPE (Sustainable Fisheries Partnership 2014).

Neither spawning stock biomass nor fishing mortality estimates are available and no reference points are defined for the stock. As mentioned above, the sustainability criterion for this species consists in letting 20% of the population (as assessed at the beginning of the year) escape for reproductive purposes. However, the stock is considered healthy. Managers comply fully with scientific advice. In general, landings are below the set TACs (Sustainable Fisheries Partnership 2014), implying that fishers are compliant. For example the reported catch for 2012 was 497,462 tonnes against a TAC of 500,000 tonnes (Sustainable Fisheries Partnership 2014).

Bycatch is considered null due to the selectivity of the automated jigs and the interaction with the seabed ecosystem is regarded as minimal. There are no records of impacts on ETP species and bycatch is zero. Ecosystems based approaches have shown that growing numbers of jumbo flying squid is not the immediate cause to diminishing numbers of hake (Sustainable Fisheries Partnership 2014).

The California market squid (*Doryteuthis (Loligo) opalescens*) occurs along the US West Coast and is California's largest fishery. Since 1986, nearly all California market squid have been fished using purse seine, drum seine, lampara and brail nets. The species is a short-lived (± 9 months) and has been an important commercial species in the region since the 1860s. The market squid fishery in California is comprised of a northern and a southern component. The northern fishery is located around Monterey Bay and typically operates from April through November, while the southern fishery operates around the Channel Islands and coastal areas and typically runs from October through March (Porzio & Brady, 2008). The California Department of Fish and Game (CDFG) manages the fishery in consultation with the industry, while the Pacific Fishery Management Council monitors the fishery. Market squid landings were over 127 500 tonnes in 2011, down slightly from a record high of 130 851 tonnes in 2010 (NMFS, 2012). These landings are higher than the set Annual Catch Limit and indicate that fishers are not very compliant or that enforcement is not very effective.

Factors affecting market squid abundance are not well understood, and the effects of fishing mortality on the stock are unclear and there are no estimates of biomass. The population fluctuates markedly from year to year, largely in apparent response to environmental factors. During El Niño events, the fishery has declined precipitously by an order of magnitude and more. However, it recovers typically within a few years, particularly in response to La Niña events (Zeidberg et al. 2006). Essentially the fishery is managed by means of seasonal quotas, based entirely on fishery dependent data. However, the quotas are not set using any analytical model with projections and uncertainty. Until 2012 the stock status was largely unknown (Stewart & Port-Minner, 2010, MBA 2014). A new analytical approach, the Egg Escapement Method, has been developed and is being used as an assessment tool (Dorval et al. 2008). The estimates of egg escapement are evaluated in the context of a "threshold" that is believed to represent a minimum level that is considered necessary to allow the population to maintain its level of abundance into the future (i.e., allow for "sustainable" reproduction year after year). In practical terms, the Egg Escapement approach can be used to evaluate the effects of fishing mortality (F) on the spawning potential of the stock, and in particular, to examine the relation between the stock's reproductive output and candidate proxies for fishing mortality that results in maximum sustainable yield (FMSY). 'Escapement' is defined as the proportion of a female squid's lifetime fecundity that is spawned, on average, before the female is captured in the fishery. More recent research efforts have developed an analytical approach for computing estimates of absolute abundance of the spawning population using relatively limited information, i.e. catch and biological time series data, and fishing mortality estimates inferred from the eggs-per-recruit methods (Dorval et al. 2013). This per recruit analysis represents a potentially effective approach for monitoring reproductive outputs and for aiding stock status determinations for market squid (Dorval et al. 2013). Proxies for limit reference points and target reference points have recently been set. These represent the minimum biomass of a stock, below which might endanger self-renewal, and the maintenance of the stock at levels consistent with B_{MSY}, respectively. A proxy for the Limit Reference Point was F_{MSY} resulting in egg escapement of ≤ 30%, while the proxy for the Target Reference Point is the MSY, set at F_{MSY} resulting in egg escapement ≥ 30% (PFMC 2011b).

The following are the harvest control rules for market squid (CDFG 2005; PFMC 2011b):

MFMT	F_{MSY} resulting in Egg Escapement ≤ 30%
MSY	F_{MSY} resulting in Egg Escapement ≥30%
ABC	F_{MSY} resulting in Egg Escapement ≥30%
ACL	107,047 tonnes

MFMT: Maximum Fishing Mortality Threshold; the level of fishing mortality (F), on an annual basis, above which overfishing is occurring.
MSY: Maximum Sustained Yield; the largest long-term average catch that can be taken from a stock under prevailing ecological, environmental and fishing conditions.
ABC: Acceptable Biological Catch; the range of allowable catch for a species
ACL: Annual Catch Limit

At maximum peaks of abundance, the total spawning stock including both female and male squid may range between 215,000 and 254,000 tonnes in the southern regions (Santa Barbara and San Diego). In some cases, stock biomass varies by region from one to two orders of magnitude. The current imposed catch limit of 107,047 mt represents an annual quota for the entire California fishery in a fishing season (CDFG 2005). Once the imposed catch limit is reached the fishery is shut down. Studies have indicated that market squid endure very high natural mortality rates, and that the adult population is composed almost entirely of new recruits made up of multiple cohorts. Even in the absence of fishing, the entire stock replaces itself semi-annually, so the stock is entirely dependent on successful spawning from each generation coupled with good survival of recruits to adulthood.

The fishery is further controlled by restrictions on lights, weekend fishing, and closed areas. Bycatch in the market squid fishery is generally very low (<2%) and is most commonly comprised of other coastal pelagic species such as Pacific mackerel, Pacific sardine, northern anchovy and Jack mackerel. None of these species are considered overfished or otherwise jeopardized by the market squid fishery (PFMC 2011a). Some benthic species such as stingrays, bat rays, brittle stars, and croaker are also caught occasionally in the purse seine nets, but most of these are released alive.

The purse seine fishery is conducted on sandy and muddy substrate and there is some interaction with the benthos. Although several state MPAs protect market squid spawning grounds, there are no regulations to reduce the incidence of bottom contact by purse seine nets. The greatest concern associated with purse seine nets contacting the bottom in sandy habitats are disruption of the squid's complex mating and egg laying behaviors, as well as dislodging egg capsules from their attachments to the sandy substratum (Young et al. 2011). Efforts are underway to assess the ecological impacts of the fishery (Porzio & Brady, 2008).

According to the Monterey Bay Seafood watch report (MBA, 2012) the impact of this fishery on seabirds is extremely low (16 incidents in 2012 and all were returned alive).There are some records of occasional interactions with ETP species, mainly dolphins and sea lions, but injuries are not serious.

Market squid are an integral part of the food web. Predators from many trophic levels utilize both small pelagic fishes, such as northern anchovy and sardine, and squid as either a primary or supplementary food source (CDFG 2005).Similarly market squid feed on a variety of prey during their life cycle (CDFG 2005). At present, the dynamics of many of these trophic relationships for squid are not well understood, although this is being actively researched by the California Department of Fish and Game. At this stage, however, more information is needed to understand how or if the current management measures protect ecosystem structure and function. Though the ecosystem role of market squid is not considered in its management, there are some positive ecosystem-based management steps being taken in the region (MBA 2012).

The fishery is in the process of seeking MSC certification. The first assessment of the fishery according to the MSC standards was initiated by the California Ocean Science Trust in 2013 (Anon 2013a). This culminated in the California squid FIP that has driven the recent scientific and management initiatives from 2013 to 2015 (Anon. 2015).

The Argentine shortfin squid, *Ilex argentines* is one of the most important global squid species, with annual catches of between 550 000 and 750 000 tonnes (Laptikhovsky et al. 2001). They reproduce and die quickly, often within one year, a lifecycle (similar to all species examined here) that potentially buffers them from heavy fishing pressure (SAFINA 2014). The lifecycle of Argentine Squid is integrally tied to the oceanography of the Southwest Atlantic, which includes the Falkland, Brazil, and Antarctic Circumpolar Currents. Inter-annual changes in the convergence of the Falkland and Brazil Currents create variability in oceanographic conditions (e.g., sea surface temperature) in the squids' hatching habitat, which greatly influences the abundance of squid in the fishable population from year to year (Laptikhovsky et al. 2001).

Shortfin squid inhabit both continental shelf and oceanic waters off Eastern South America from 20°–55° S, and eastward to 40–45° W (Arkhipkin, 1999). Within this range, three major intraspecific stocks are recognized: the winter-spawning South Patagonian stock (SPS), which spawns in continental slope waters; the winter-spawning Bonaerensis-North Patagonian stock (BNS), which spawns in continental shelf waters; and a summer spawning stock (SSS). The most commercially important population, the South Patagonian or winter-spawning stock, spawns and hatches between 28 and 38° S (Laptikhovsky et al. 2001). South American and Asian distant-water jigging vessels dominate the fishery, which occurs mainly off the coasts of Argentina and the Falkland Islands and in international waters. (SAFINA 2014). Squid are lured to the surface by jigging vessels using underwater and surface lamps (FIG 2004).

Abundance of Argentine Squid is difficult to estimate due to its short lifespan, complicated population structure, and the high inter-annual variability in its population size. Historically estimates of total biomass of *I. argentines*, based on trawl data, have ranged from 60 000 to 2.6 million tonnes (Haimovici et al. 1998). However, it is not possible at this stage to estimate long-term catch limits based on maximum sustainable yield, because variable, inter-annual changes in the environmental conditions largely determine year-to-year abundance of Argentine Squid (Basson et al. 1996). Managers therefore use recruitment data gathered from annual surveys to infer information about the size of the fishable population for the coming year's fishery. However, highly variable catches from a high of 1.14 million tonnes in 1999 to around 500 000 tonnes in 2002 would indicate that the methods used to infer the fishable biomass are far from optimal. On a more localized scale the catches in the Falklands illustrate to what extent environmental conditions impact on catches. Between 2001 and 2002 catches plummeted from 150 523 tonnes to 12 372 tonnes and then recovered to 103 330 tonnes in 2003. During 2002, the Falkland Current was relatively intense and it has been suggested that the resulting low sea surface temperatures prevented the squid from moving into the Falkland Islands' fishing zones (SAFINA 2014). The species is not regarded as being over fished by any of the management agencies that oversee the management of South Atlantic fisheries (SAFINA 2014).

Most of the catch is taken by jigging vessels (using automated jigging machines) and lights as an attractant. Bottom trawling vessels in Argentine and Falkland Islands waters catch squid as bycatch. For example, in 2003 trawlers took 1 622 tonnes of Argentine Squid, whereas jigging vessels took 101,868 million tonnes (FIG 2004). The impact of this huge fishery on the environment is considered to be minimal and that the habitat would remain robust and viable to support the species and that there is no need for any innovations to reduce the impact of the gear on the habitat (SAFINA 2014).

Management of the fishery is spread among two inter-country commissions and several national governments. The Technical Commission for the Maritime Front establishes the dates for the Squid-fishing season in the Argentinean/Uruguayan Common Fishing Zone. The South Atlantic Fisheries Commission (SAFC), collects data on fishing effort, coordinates joint research, and recommends management measures to Argentina's and the Falkland Islands' fisheries agencies (SAFINA 2014).

The Falkland Islands Fishery Department (FIFD) manages the fishery in the Falkland Islands Interim Conservation and Management Zone (FICZ), which covers a 150 nautical mile (nm) radius, and in the Outer Conservation Zone (FOCZ), which extends the managed area to 200 nm to the north, east, and south of the islands. The fishing season in Falkland Islands waters is from 15 February to the 15 June. The conservation target set by managers is 40,000 metric tons, and managers control fishing effort with license requirements that allow fishing for a fixed period of time. The FIFD monitors catches on a daily basis and closes the fishery when total catches approach the conservation threshold (FIG 2004).

In Argentina, the Federal Fisheries Council establishes the objectives for scientific and technical research, and the National Institute for Fisheries Research and Development carries out the research and population assessments. Illegal fishing by foreign vessels is a problem in Argentina’s squid fishery.

This results in a management dichotomy. On the one hand the squid resources of coastal states are as well managed as possible and which have demonstrated success in achieving conservation and sustainability goals and on the other hand, the high seas component is essentially unregulated. The degree to which Illegal, Unreported, and Unregulated fishing for Argentine Squid occurs in national and international waters is unknown.

Bycatch in the jigging fishery of coastal states is as little as 0.1% of the total catch, and incidentally caught species include the squids, *Martialia* and *Moroteuthis* species and finfish. Bycatch in daytime squid trawling operations (which are often carried out by the same vessels that jig for squid at night) generally constitutes less than 5% of the total catch and includes juvenile *Loligo gahi*, common hake, southern cod, southern blue whiting, whiphake, and grenadier (SAFINA 2014).

There is anecdotal evidence of interactions between Argentine squid jigging vessels and seabirds. In 2003, Falklands Conservation, a non-profit environmental organization, conducted a pilot study to explore this issue. It found that jigging lures occasionally hook penguins, but fishers are generally able to release the birds with only minor puncture wounds from the lures. Fisheries observers have not recorded any direct seabird mortalities (SAFINA 2014).

Squid diagnostic

In all squid fisheries, there is generally very little (if any) robust data on biomass, biomass reference points and fishing mortality rates. Management measures are based largely on recruitment data and only in California and in South Africa are there any credible attempts to quantify biomasss or proxies for biomass and Fishing mortality. However, all fisheries seem to be managed on a sustainable basis and this is largely due to the life history characteristics of the species. Environmental impacts on abundance are clearly highly significant in all cases and this is receiving much attention.

The impact of squid fishing on the substrate and the environment in most instances is negligible. This is largely because of the gear types that are used, viz. jigging and purse seine trawling. There is some demersal trawling in the Argentine fishery and there is some interaction between purse seine nets and the seabed in the California fishery. Bycatch levels in all the squid fisheries are below 5%. Bycatch is mainly returned alive in all but the Argentine fishery, where there is great uncertainty regarding the fate of bycatch in the high seas fishery, which is largely unregulated and which undermines the by catch management plans of the regulated fisheries in Argentina and the Falklands.

Science based management plans are in place for all squid fisheries, except for the unregulated, high seas sector of the Argentine shortfin squid fishery and hence in comparison to the three other fisheries the Argentine fishery received a lower score for management. Compliance in the California and the Argentine fisheries has been brought into question, and nothing is known about the level of compliance in the Peruvian fishery. It is however well known that compliance in the RSA fishery is 100%. MCS in all instances is far from optimal and can be improved in all instances.

The results show that the RSA chockka squid fishery with 13.7 points ranks in first place followed by the Peruvian flying jumbo fishery, the California market and the Argentine shortfin squid fisheries. The South African fishery takes first place mainly because of the additional and voluntary impact mitigation measures, low habitat impacts, the high level science that underlies management efforts and the high levels of compliance. While every effort is being made by Argentina and the Falkland Islands to manage the resources under their jurisdiction the fishery is jeopardized by the highly migratory nature of the species, which exposes the stocks to unregulated fishing and associated problems of under reporting, impact on ETP and bycatch species.

Table 13. Composite scoring table for the RSA chokka squid fishery, the Peruvian jumbo flying squid, the California market squid and the Argentine / Falkslands shortfin squid fisheries.

		Points	RSA	Peru Jumbo	California	Argentina
A	**Stock status MAX**	**10**	chokka squid	flying squid	market squid	shortfin squid
A1	Non-fully exploited (B>60% of pristine,CPUE>60% of initial rate,SSB>40% of unfished B)	**10**				
A2	Fully exploited (B=40-60% of pristine, CPUE = 40-60% of initial rate, SSB=20-40% of initial)	**8**				
A3	Stock status unknown but resource managed on a sustainable basis	**7**	7	7	7	7
A4	Multi species fishery with under, fully and over exploited stocks	**6**				
A5	Over exploited (B<40% of pristine, SSB<20% of unfished B, but showing signs of recovery)	**4**				
A6	Over exploited (same as above but B, SSB, CPUE and size composition trends decreasing)	**1**				
B	**Ecosystem impact mitigation MAX**	**20**				
B1a	Low habitat impact	**3**	3	3		
B1b	Medium habitat impact	**2**			2	2
B1c	High habitat impact	**1**				
B2a	Habitat impact mitigation measures implemented or not required	**2**				
B2b	No habitat impact mitigation measures implemented	**1**	1	1	1	1
B3a	Bycatch <5% of catch	**3**	3	3	3	3
B3b	Bycatch <10% of catch	**2**				
B3c	Bycatch >10% of catch	**1**				
B4b	Impact on ETP species understood / studied and mitigation measures implemented	**2**	2	2	2	2
B4c	Impact on ETP species not well understood and no mitigation measures implemented	**0**				
B5a	Voluntary habitat/ecosystem impact mitigation measures implemented	**3**	3			
B5b	No voluntary habitat/ecosystem impact mitigation measures implemented	**1**		1	1	1
B6a	By catch management plan in place	**2**	2	2	2	
B6b	No by catch management plan	**0**				0
B7a	Fish bycatch mitigation measures implemented	**2**	2	2	2	2
B7b	No fish bycatch mitigation measures implemented	**0**				
B8a	Fish bycatch mainly retained	**3**	3	3	3	
B8b	Fish bycatch partially retained/discarded	**2**				2
B8c	Fish bycatch mainly discarded	**1**				
C	**Effective Management MAX**	**20**				
C1a	Regular (annual or biennial) assessments of B, SSB and F or other	**3**				
C1b	Irregular assessments B, SSB and F or other	**2**	2	2	2	2
C1c	No assessments	**0**				
C2a	Science based management plan in place in accordance with the precautionary principle	**2**	2	2	2	2
C2b	Major differences between scientific advice and management plans	**0**				
C3a	Ecosystems approach to management applied or actively researched	**2**	2	2	2	2
C3b	Ecosystems approach to management neither applied nor researched	**0**				
C4a	Best management methods employed (TAC,TAE,ITQs, Closed seasons / areas)	**2**	2	2	2	2
C4b	Non optimal management measures employed	**1**				
C5a	Industry actively involved in the management of the resource	**2**	2	2	2	
C5b	Industry not actively involved in the management of the resource	**0**				0
C6a	Fishers compliant (Catch vs TAC, over or under reporting of catches)	**2**	2			
C6b	Fishers not very compliant	**1**		1	1	1
C7a	Strong MCS measures employed	**2**				
C7b	Weak MCS measures employed	**1**	1	1	1	1
C7c	No MCS measures employed	**0**				
C8a	Sea based observer programme in force (ALL Vessels Full Time)	**3**				
C8b	Sea based observer programme in force (SOME Vessels Full Time	**2**				
C8c	Sea based observer programme in force (SOME Vessels Occasionally)	**1**	1	1	1	1
C8d	No sea based observer programme	**0**				
C9a	Landbased inspection programme in force (ALL landings)	**2**				
C9b	Landbased inspection programme in force (SOME landings)	**1**	1	1	1	1
C9c	No landbased inspection programme in force	**0**				
C9c	No landbased inspection programme in force	**0**				

General conclusions

The results of this study have clearly shown that the science, the ecosystem approach to management, and the co-management structures and measures that have been put in place and that underlie the management of the South African fisheries are of the highest order. South African scientists are considered leaders in the ecosystem approach to fisheries management and the country is one of the few that regularly undertakes Ecosystem Risk Assessments of its fisheries.

This benchmarking exercise has shown that in many instances the South African fisheries are outranked by the slimmest of margins. Within the greater mosaic of complex management systems, stock and environmental variability and uncertainty, these small differences are of little meaning. Tables 14 and 15 benchmark the South African fisheries against its competitors. Table 14 shows the rankings of the fisheries in the various sectors and Table 15 presents the overall percent score for each South African fishery relative to the scores of the three top ranked fisheries across the three evaluation criteria.

Table 14. The rankings of the individual fisheries within the various sectors.

FISHERY RANK	Offshore trawling	Small pelagic	Large pelagic	Rock lobster	Squid
1	Alaska pollock	Argentina anchovy	USA albacore	W. Australia	RSA chokka
2	New Zealand hoki	RSA small pelagic	RSA tuna	RSA south coast	Peru jumbo flying
3	RSA hake	Peru anchovy	Japan tuna	Baja California	California market
4	Argentina hake	Chile Jack mackerel	Indonesia tuna	RSA west coast	Argentine shortfin
5				Brazil	

*MSC certified

Table 15. The ranking and comparative percent scores of South African fisheries relative to the top, 2nd and 3rd ranked fisheries.

RSA Fishery	Offshore trawl	Small pelagic	Large pelagic	West coast RL	South coast RL	Squid
Rank	**3**	**2**	**2**	**4**	**2**	**1**
RSA Score (%)	80	82	78	68	74	82
Top ranked (%)	92	84	86	86	86	---
2nd (%)	84	---	---	74	---	76
3rd (%)	---	60	68	66	66	74

The monitoring activities that underlie the research and management foundation for all South Africa major fisheries resources are summarized in Table 16 (Hutchings et al. (2009). The data obtained from the monitoring activities provide the means to analyse trends in the population in an agreed upon manner that allow Operational Management Procedures to be developed to maintain stocks at or above certain target levels or to rebuild depleted stocks to a target level. This is done through a combination of input controls such as a total allowable effort, gear restrictions, closed areas and seasons or through output controls, such as a total allowable catch, or bycatch precautionary upper catch limit, daily bag and size limits (Hutchings et al. 2009). These may be broken down further into individual rights allocations. However, this is beyond the scope of this study.

Table 16. Summary of the fishery dependent and fishery independent monitoring activities for major South African fishing sectors (Hutchings et al. 2009).

Resource	**Catch**	**Effort**	**CPUE**	**VMS**	**Biological**	**Observer (on board)***	**Observer (landing site)**	**Direct surveys**	**Indirect surveys**
Offshore trawl	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Small pelagics	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
WC rock lobster	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
SC rock lobster	Yes	Yes	Yes	Yes	Yes	Yes	**NO**	Yes	Yes
Squid	Yes	Yes	Yes	Yes	Yes	Yes	**NO**	Yes	Yes

***The RSA onboard observer programme was halted in 2011**

On the basis of effective management and environmental responsibility the rankings show that the South African fisheries in each of the sectors are among the top performers on a global scale. Three of the fisheries were ranked 2nd, while the squid fishery was ranked in pole position and one each was ranked in the 3rd and 4th positions. Several South African fisheries stand out. For example, the SA south coast rock lobster fishery has a higher overall score than the MSC certified Baja California red rock lobster fishery. The higher score is essentially a consequence of the high profile ecosystems based science that underlies management. For the same reasons as well as the high degree of compliance, the South African chokka fishery scores significantly above any of its competitors and would most likely be fit for MSC certification. Based on the quality of the science underlying its management, the high degree of compliance, zero bycatch and the negligible ecosystems impacts it is arguably in a better position to achieve MSC certification than the California market squid fishery. The SA small pelagic fishery, which ranks second by one point behind the MSC certified Argentina anchovy fishery, stands out as a model of complex yet effective management. The fishery is the only one of its kind in the world that manages target and bycatch species simultaneously and successfully. It is our opinion that the fishery is also fit for MSC certification. Benchmarking the SA hake fishery against its competitors was interesting. In all respects, there was little difference (1 point) between the NZ hoki and the SA hake fishery. Both are managed extremely well but both cannot compete against the Alaskan Pollock fishery with respect to MCS and the excellence of the Alaskan observer programme.

Then, of course, there is the west coast rock lobster fishery, which is of great concern to all stakeholders. This resource has suffered in the past from overfishing, illegal fishing, and environmental / ecological changes. For this reason, the status of the resource is lower than that which would result in the highest yield and is overexploited. This does not mean, however, that the resource is doomed – it just means that the resource has to be rebuilt through a careful and long term scientific co-management approach that simultaneously considers the realistic expectations of the communities that depend on it. Contributing reasons for the demise of the fishery are many and varied, ranging from the biological to anthropomorphic. The West Coast lobster resource, similar to the abalone resource, are resources that have been harvested by traditional fisher communities who have in the past (pre 1994) been denied an equitable share of the economic benefits. It is our opinion that this was the underlying cause of the disregard for applied management measures and rampant poaching in both sectors. The management inefficiencies of the very past, coupled with political interference, corruption and community frustrations and the snail's pace of fisheries reform and developing equitable solutions and the States inability or unwillingness to control illegal harvesting has led to the virtual collapse of both the rock lobster and the abalone fisheries. Fortunately, the excellent science and co-management measures that underlie the current Operational Management Procedure have already contributed significantly towards achieving the goals of rebuilding the stock and confidence in management. However the goal can only be scored if there is complete buy in by all stakeholders.

Two South African fisheries, namely the offshore trawl fishery and the tuna long line fishery have made enormous strides in reducing seabird mortalities to negligible levels and truly stand out in comparison to their global peers.

The generally high degree of scientific excellence underlying the management of South African fisheries and compliance by some sectors with management measures as noted (and scored) in this study is supported by the findings of Pramod et al. (2006). Their (op cit.) estimation of compliance of South African fisheries with Article 7 of the UN Code of Conduct for Responsible Fishing showed that the scores for fisheries management objectives, management framework and adherence to the precautionary principle were internationally highly competitive.

In conclusion and taking cognizance of environmental and recruitment variability and other uncertainties this benchmarking exercise would suggest that the management of South Africa's major fisheries, except for the west coast rock lobster, is on par with and in some instances is better than the best performing global fisheries. However, there is a serious need for Government to recognise that good science is not the only ingredient for the sustainability and good management of our fisheries. The social and economic dimension of sustainable fisheries and good management were not considered in this study but they are as importance as the underlying natural and mathematical sciences. While there are concerns about the current scientific expertise in the Fisheries Division of DAFF and about the way marine science is fragmented into two separate Government Departments , there is even greater concern whether Fisheries has the in-house capacity to deal with the social and economic dimensions of management. Similarly there is concern about the current state of MCS and the deplorable state of sea going support and the lack of confidence in DAFF by various stakeholders. Some matters that require the immediate attention of the Minister are;

1. To re-instate the observer programme
2. To appoint an agency to investigate claims of corruption within the inspectorate and elsewhere within the department and root it out. If this is not done then the department will never regain

the respect and confidence of its stakeholders, and this undermines the ability to manage properly.

3. To take control of and maintain its fleet of modern patrol vessels, which for most of the time, are out of operation.
4. To call for an independent review of the structure and function of the Fisheries Division and of marine research within Government.

Finally, it must be highlighted that the good marks scored by some of the fisheries are to a large measure due to the strong and proactive sectoral associations. These associations have played a major role to maintain the stature of our fisheries by proactively supporting observer programmes, undertaking surveys, scientific research and promoting self- regulation.

References

Abraham, E. & Thompson, F. (2012). Captures of birds in hoki trawl fisheries, in the New Zealand Exclusive Economic Zone, during the 2010-11 fishing-year. Retrieved from http://data.dragonfly.co.nz/psc/v20121101/birds/hoki-trawl/all-vessels/eez/2011/

Andrews, J., Groeneveld, J and Pawson, M. 2015. South African hake trawl fishery. Public Certification Report. INtertek Fisheries Certificatgion Report, Ref 82007. 335p. Report available at www.msc.org/track-a-fishery/fisheries-in-the-program/certified/south-atlantic-indian-ocean/south-africa-hake-trawl-fishery/south-african-hake-second-reassessment-documents/20150526_PCR_HAK108.pdf

Annon. 2013a. Market Squid (Loligo (Doryteuthis) opalescens). Accessed at http://opc.ca.gov/webmaster/ftp/project_pages/Rapid%20Assessments/Market%20Squid.pdf

Annon.2015. California Squid Fishery Improvement Project. Accessed at https://sites.google.com/site/californiasquidfip/home

APA. 2011. The Alaska Pollock Fishery. A Case Study of Successful Fisheries Management. pp 1-2.

Arkhipkin, A.I. and D.A.J. Middleton. 2002. Inverse patterns in abundance of Illex argentines and Loligo gahi in Falkland waters: possible interspecific competition between squid? Fisheries Research 59: 181-196.

Ashford, J., Serra, R., Saavedra, J.C., Letelier, J. 2011. Otolith chemistry indicates large-scale connectivity in Chilean jack mackerel (Trachurus murphyi), a highly mobile species in the Southern Pacific Ocean, Fisheries Research 107(1–3): 291–299.

Bartoo, N., Blyth-Skyrme, R. & Laurs, M. 2012. American Albacore Fishing Association North Pacific Albacore Pole & Line and Troll/Jig Fishery. MSC Final Determination Report (Ref 82022-NP). Intertek Moody Marine Int. Nova Sotia, Canada. 159p.

Basson, M., J.R. Beddington, J.A. Crombie, S.J. Holden, L.V. Purchase, and G.A. Tingley. 1996. Assessment and management techniques for migratory annual squid stocks: the Illex argentines fishery in the Southwest Atlantic as an example. Fisheries Research 28: 3-27.

Bergh, M. 2014. 2014 status of South African lobster and squid fishery. OLRAC Report . 7p.

Birdlife Afreica. http://www.birdlife.org.za/conservation/seabird-conservation/albatross-task-force

BOI & MBA (Blue Ocean Institute and Monterey Bay Aquarium) 2013. Yellowfin tuna, Thunnus albacares. Indonesia, Western Central Pacific. Pelagic Longline. 42p. http://www.seafoodwatch.org/m/sfw/pdf/reports/mba_boi_yellowfintunaindonesiareport.pdf

Braga RM, de Lima JAR, da Silva TS, Fernandes L, de Lima RCR. 2012. Proposals for a moratorium on lobster fishing until 2014. Accessed at http://prainhadocantoverde.org/wp-content/uploads/2012/10/LOBSTER-MANAGEMENT-2014.doc

California Department of Fish and Game (CDFG). 2005. Final Market Squid Fishery Management Plan. State of California Resources Agency, Department of Fish and Game, Marine Region. 124p.

Cannon,J. 2007. FishSource Scores. How they're calculated and what they represent. Ver.1. Fisheries Partnership. 20p. (www.sustainablefish.org).

Cárdenas, L., Silva, A. X., Magoulas, A., Cabezas, J., Poulin, E., Ojeda, F.P. 2009. Genetic population structure in the Chilean jack mackerel, Trachurus murphyi (Nichols) across the South-eastern Pacific Ocean, Fisheries Research 100: 109–115.

Carvalho, F.M. and Castello, J.P. 2013. Argentine anchovy (Engraulis anchoita) stock identification and incipient exploitation in southern Brazil. Lat.Am.J. Aquat.Res. 41(5) 820-827. (DOI: 103856/vol41-issue5-fulltext-2)

CeDePesca 2014a. Argentine-Uruguayan Hake Improvement Project. http://cedepesca.net/promes/whitefish/argentine-uruguayan-hake/

CeDePesca 2014b. Chilean Jack Mackerel CeDePesca Improvement Project. http://cedepesca.net/promes/small-pelagics/chilean-jack-mackerel/

Childers, J., Snyder, S. & Kohin, S. (2011). Migration and behaviour of juvenile North Pacific albacore (Thunnus alalunga). Fisheries Oceanography, V. 20, pp. 157-173.

Christian, C., Ainley, D., Bailey,M.,Dayton,P.,Hocevar,J.,LeVine,J., Nouvia, C., Velarde, E., Werner, R and Jacquet, J. 2013. A review of formal objections to Marine Stewardship Council fisheries certifications. Biological Conservation 161: 10–17.

Clarke, S. 2011. A status snapshot of key shark species in the Western and Central Pacific and potential management options. Western and Central Pacific Fisheries Commission, Scientific Committee, Seventh Regular Session, 9-11 August 2011. WCPFCSC7-2011/EB-WP-04. Available online http://www.wcpfc.int/node/3218

Cochrane, K.L., Oliver, B and Sauer, W. 2014. An assessment of the current status of the chokka squid fishery in South Africa and an evaluation of alternative allocation strategies. Marine Policy, 43: 149-163.

DAFF 2012a. Status of the South African marine fishery resources. Department of Agriculture, Forestry and Fisheries. 71p.

DAFF 2012b. Tuna longline and tuna pole website contributions. http://www.nda.agric.za/doaDev/sideMenu/fisheries/03_areasofwork/Resources%20Research/Tuna%20longline%20and%20tuna%20pole%20DAFF%20website.pdf

DAFF, 2014. Report from the Inshore Trawl By-catch Task Team. March 2014. FISHERIES/2014/MAR/SWG-DEM/03. 6p.

Daneel, C., & Attwood, C., 2013. Bycatch in South Africa's Offshore Trawl Fishery as Determined from Observer Records. Draft DEG report, January 2013. 45p.

Davies, N., S. Hoyle, S. Harley, A. Langley,P. Kleiber, and J. Hampton. 2011. Stock assessment of bigeye tuna in the western and central Pacific Ocean. WCPFC-SC72011/SA- WP-02. Available online http://www.wcpfc.int/node/3218.

Deep Water Group Limited 2012. Sustainable management of New Zealand's hoki fisheries. 21p.

Deep Water Group Ltd 2013. New Zealand Deepwater fisheries management practices. 2013/01: 28p.

Deere. C. 1999. Eco-labelling and sustainable fisheries. IUCN: Washington, D.C. and FAO: Rome. ISBN: 28317-0507-X. 32p.

De Lestang, S., Caputi, N., How, J., Melville-Smith, R., Thomson, A. and P. Stephenson. 2012. Stock Assessment for the West Coast Rock Lobster Fishery. Fisheries Research Report No. 217. Department of Fisheries, Western Australia.

De Lestang, S., Rossbach, M, Baudains, G. and Trinnie, F. 2014. West coast rock lobster fishery status report. http://www.environment.gov.au/system/files/pages/6355d357-bb5d-4411-a33d-c0667ed79c92/files/west-coast-rock-lobster-appendix-2b-state-fisheries-report-2013-14.pdf

Department of Fisheries (DOF). 2011. Governance of the Western Rock Lobster Fishery and Marine Stewardship Council Principle 3 Effective Management. Fisheries Occasional Publication No. 96, 90p.

Department of Fisheries (DOF). 2012. West Coast Rock Lobster Managed Fishery – Harvest Strategy and Decision Rules Proposals Under a Quota Management System. Western Australian Department of Fisheries.

Díaz E, García C, Espinoza D, Guevara-Carrasco R, Csirke J, Ñiquen M, Vargas N, Argüelles J. 2010.- Assessment of the north – center stock of Peruvian anchoveta (Engraulis ringens Jenyns) using an age - structured model. Bol Inst Mar Perú, 25(1-2):57-61. http://www.imarpe.pe/imarpe/archivos/informes/imarpe_boletin_vol25_num1_2.pdf

Díaz, E., 2009. Assessment and Management of Peruvian anchoveta (Engraulis ringens). Peruvian Marine Research Instituite (IMARPE). http://www.imarpe.gob.pe/paita/reportes/cedepesca/docs/13.pdf

Dorval, E., Crone, P.R., and McDaniel, J.D. 2013. Variability of egg escapement, fishing mortality and spawning population in the market squid fishery in the California Current Ecosystem. Marine and Freshwater Research. 64(1): 80-90.

FIG (Falkland Island Government). 2004. Fishery Department Statistics, Volume 8 (1994-2003). Available at: http://www.fis.com/falklandfish/fifdbull.htm

Fairweather, T. van der Lingen, C. D. Booth, A. J. and Drapeau, L. and J. J. van der Westhuizen. 2006. African Journal of Marine Science 28(3 & 4): 661–680

FAO 1995. Code of Conduct for Responsible Fisheries Rome, FAO, Rome. 41p.

FAO 2004. The State of World Fisheries and Aquaculture. Available at: http://www.fao.org/sof/sofia/index_en.htm.

FAO 2006. Report of the Fifth regional workshop on the assessment and management of the Caribbean spiny lobster. FAO Fisheries Report No. 826. 19–29 September 2006. Mérida, Yucatán, Mexico. 109 pp. ftp://ftp.fao.org/docrep/fao/010/a1518b/a1518b00.pdf

FAO 2011a. Code of Conduct for Responsible Fisheries. Special Edition. FAO. Rome. 91 p.

FAO 2011. Review of the state of world marine fishery resources. FAO Fisheries and Aquaculture Technical Paper No. 569. Rome, FAO. 2011. 334 pp.

FAO 2014. The State of World Fisheries and Aquaculture. Food and Agriculture Organization of the United Nations, Rome. 243pp.

Forest & Bird (2012) Best Fish Guide 2012-2013: How sustainable is New Zealand seafood? (Ecological Assessments). Royal Forest and Bird Protection Society of New Zealand Inc, Wellington.

Garmendia, E., Prellezo, R,. Murillas, A.,, Escapa, M. and Gallastegui, M. 2010. Weak and strong sustainability assessment in fisheries. Ecological Economics 70: 96–106.

Gerlotto, F., Gutérrez, M., Bertrand, A. 2012. Insight on population structure of the Chilean jack mackerel (Trachurus murphyi), Aquatic Living Resources 25: 341–355 http://journals.cambridge.org/download.php?file=%2FALR%2FALR25_04%2FS0990744012000368a.pdf

Gislason, H. 2003. The effects of fishing on non-target species and ecosystem structure and function, University of Copenhagen, Danish Institute for Fisheries Research, 21p. ftp://ftp.fao.org/fi/document/reykjavik/pdf/15Gislason.pdf

Glazer, J. and D. S. Butterworth. 2006. Some refinements of the assessment of the South African squid resource, Loligo vulgaris reynaudii. Fisheries Research 78: 14-25.

Groeneveld JC. 2003. Under-reporting of catches of South Coast rock lobster Palinurus gilchristi, with implications for the assessment and management of the fishery. South African Journal of Marine
Science 25: 407–411.

Habibi, A. 2014. Indonesian tuna fisheries improvement program: Progress on Principle 1. MSC, Development World Conference, Bali 14-16 April 2014.

Haimovici, M. et al. (1998). "Illex argentinus." Squid Recruitment dynamics: the genus Illex as a model, the commercial Illex species and influences on variability 376: 27-58.

Hansen, J., Garciarena, D. & C. Buratti, 2014. Dinámica poblacional de la anchoíta bonaerense entre
1990 y 2013. Recomendaciones de captura máximas en el año 2014. Inf. Téc. INIDEP S/N: 33p.

Harley, S.J., P. Williams, S. Nicol, and J. Hampton. 2011. The western and central Pacific tuna fishery: 2010 overview and status of stocks. Tuna Fisheries Assessment Report 11. New

Caledonia: Secretariat of the Pacific Community. Available online http://www.wcpfc.int/node/3218

Hutchings L., C.J. Augustyn, A. Cockcroft, C. Van der Lingen, J. Coetzee, R.W. Leslie, R.J. Tarr, H. Oosthuizen, M.R. Lipinski, M.R. Roberts, C. Wilke, R. Crawford, L.J. Shannon and M. Mayekiso. 2009. Marine fisheries monitoring programmes in South Africa. South African Journal of Science 105: 182-192.

IFFO (International Fishmeal and Fish Oil organization). 2009. The production of fishmeal and fish oil from Peruvian anchovy.

IMARPE, 2014a. Informe Análisis Poblacional de la Pesquería de Anchoveta en el Ecosistema Marino Peruano". 38 pp. http://www.imarpe.pe/imarpe/archivos/informes/info_anal_pob_anchov_1.pdf

IMARPE, 2014b. Situación actual del stock Norte-Centro de la anchoveta peruana y perspectivas de explotación para el periodo Abril - Julio 2014, 9pp. http://www.imarpe.pe/imarpe/archivos/informes/anch_situa_adic2014.pdf

IOTC (Indian Ocean Tuna Commission). 2012. Report of the Fifteenth Session of the IOTC Scientific Committee. Mahé, Seychelles, 10–15 December 2012. IOTC–2012–SC15–R [E]: 288p.

IOTC 2013. Appendix XII. Status of the Indian Ocean swordfish resource. IOTC-2013-SC16-R: 124-134.

Johnston, S.J., D.S. Butterworth, J.P. Glazer, and A. Brandão. 2011. "OMP 2011 to be used for setting TACs for the West Coast Rock Lobster fishery for the 2011+ seasons", Department of Agriculture, Forestry and Fisheries Scientific Working Group Document for WCRL, FISHERIES/2012/JUL/SWG-WCRL/10, 69p.

Laptikhovsky, V., A.V. Remeslo, C.M. Nigmatullin, and I.A. Polishchuk. 2001. Recruitment strength forecasting of the Shortfin Squid Illex Argentinus (Cephalopoda: Ommastrephidae) using satellite SST data, and some consideration of the species¡¯ population structure. Report to the International Council for the Exploration of the Sea.

Laurs, R.M., Fiedler, P.C. & D.R. Montgomery (1984). Albacore tuna catch distributions relative to environmental features observed from satellites. Deep-Sea Research, 31: 1085–1099.

Liu, B., Chen, X., Lu, H., Chen, Y. and W. Qian. 2010. Fishery biology of the jumbo flying squid Dosidicus gigas off the Exclusive Economic Zone of Chilean waters. Scientia Marina 74(4): 687-695.

Madureira, L., Castello, J., Hernandez, C., Quirez, M., Santo, E., Ruiz, W., Abdallah, P., Hansen, J., Bertolotti, M., Manca, E., Yeannes, M., Avdalov, N. and S. Amorin. 2009. Current and potential alternative food uses of the Argentine anchoita (Engraulis anchoita) in Argentina, Uruguay and Brazil. In M.R. Hasan and M. Halwart (eds). Fish as feed inputs for aquaculture: practices, sustainability and implications. FAO Fisheries and Aquaculture Technical Paper No. 518: 269–287.

Makino, M. (2011). Fisheries Management in Japan: Its Institutional Features and Case Studies. Fish and Fisheries Series Vol. 34. Netherlands: Springer.

Maree, BA, Wanless RM, Fairweather TP, Sullivan BJ & Yates O. 2014. Significant reductions in mortality of threatened seabirds in a South African trawl fishery. Animal Conservation, 17.

MBA 2012. Monterey Bay Aquarium. Seafood Watch®. Market Squid, Doryteuthis (Loligo) opalescens. 49p.

MBA 2014. Monterey Bay Aquarium. Seafood Watch® Criteria for Fisheries (Version March 2014). 80p.

MMAF (Ministry of Marine Affairs and Fisheries). 2012a. Annual report to the commission part 1: Information on fisheries, research, and statistics. WCPFC-SC8-AR/CNM33 Rev1. Available online http://www.wcpfc.int/node/4587.

MMAF. 2012b. National tuna fishery profile on the Celebes Sea (FMA 16) and Pacific Ocean (FMA 17) Indonesia. West Pacific East Asia Oceanic Fisheries Management. November 2012. Available online http://www.wcpfc.int/west-pacific-east-asia-oceanic-fisheries -management-project

MMAF. 2012c. National Tuna Management Plan. West Pacific East Asia Oceanic Fisheries Management. November 2012. Available online http://www.wcpfc.int/west-pacific-east-asiaoceanic-fisheriesmanagement-project

MSC 2009. http://www.msc.org/track-a-fishery/documents/fisheries-factsheets/aafa-tuna-ffs-us-paper-size.pdf

MSC 2009a. Fact sheet : New Zealand Hoki. www.msc.org/track-a-fishery/certified/pacific/new-zealand-hoki

MSC. 2009b. Fact sheet: Alaska Pollock. www.msc.org/track-a-fishery/certified/pacific/gulf-of-alaska-pollock

MSC 2009c. Fact sheet: South African hake trawl fishery. www.msc.org/track-a-fishery/certified/south-atlantic-indian-ocean/south-africa-hake-trawl-fishery

MSC 2012. Case study: How the Western Australian rock lobster fishery eliminated sea lion mortalities. Accessed at www.msc.org/healthy-oceans/our-solution/case-study-western-australian-rock-lobster-fishery-reducing-sea-lion-bycatch

MSC 2014a. MSC Fisheries Standard and Guidance (Extracted from the Fisheries Certification Requirements, Annexes SA-SD). Version 2.0. 314p.

MSC 2014. AAFA and WFOA North Pacific albacore tuna. Accessed at https://www.msc.org/track-a-fishery/fisheries-in-the-program/certified/pacific/aafa-pacific-albacore-tuna-north/aafa-and-wfoa-north-pacific-albacore-tuna

MSC 2015. List of all certified fisheries. Accessed at www.msc.org/track-a-fishery/fisheries-in-the-program/certified/all-certified-fisheries

MSC 2015. Japanese pole and line skipjack and albacore tuna. http://www.msc.org/track-a-fishery/fisheries-in-the-program/in-assessment/pacific/japanese-pole-and-line-skipjack-and-albacore-tuna

MSC 2015. Japan's Meiho tuna fishery enters MSC assessment. www.msc.org/newsroom/news/japans-meiho-tuna-fishery-enters-msc-assessment

MSC 2015. Australian Western rock lobster. Accessed at www.msc.org/track-a-fishery/fisheries-in-the-program/certified/south-atlantic-indian-ocean/western-australia-rock-lobster

Nel, D.C, (2007), "Ecological Risk Assessment (ERA) for the South African West Coast Rock Lobster Fishery", in D.C. Nel, K. Cochrane, S.L. Petersen, L.J. Shannon, B. van Zyl, and M.B. Honig (eds.) Ecological Risk Assessment: A Tool for Implementing an Ecosystem Approach to Southern African Fisheries, WWF South Africa Report Series – 2007/Marine/002.

Nigmatullin, Ch.M., K.N. Nesis, A.I. Arkhipkin, 2001. A review of the jumbo squid Dosidicus gigas (Cephalopoda: Ommastrephidae). Fisheries Research 54: 9-19. http://www.cephbase.dal.ca/refdb/pdf/6869.pdf

NMFS (2011a). US National Bycatch Report, First edition, revised 16 September 2011. Editors: W.A. Karp, L.L. Desfosse & S.G. Brooke. NOAA Techmical Memorandum, NMFS-F/SPO-117C. 508p.

NMFS (2011b). FishWatch- US Seafood facts; Northern anchovy (Engraulis mordax). http://www.nmfs.noaa.gov/fishwatch/species/anchovy.htm..

NMFS (2012). Pacific albacore tuna. Fishwatch. Available at: http://www.fishwatch.gov/seafood_profiles/species/anchovy/species_pages/northern_anchovy.htm (accessed April 2015).

NMFS (National Marine Fisheries Service). 2012. List of Fisheries (LOF) - CA Squid purse seine fishery. Available at: http://www.nmfs.noaa.gov/pr/interactions/lof/final2012.htm

NOAA (2011a). List of fisheries for 2012. National Oceanic and Atmospheric Administration, Federal Register, 76 (229): 73912 – 73953.

NOAA (2011b). Federal Regulations, Title 50: Wildlife and Fisheries, Part 660, CFR 223.206(d)(1). National Oceanic and Atmospheric Administration. http://ecfr.gpoaccess.gov/cgi/t/text/textidx?c=ecfr;sid=f4cb71ce126d32e75c9bc21398ee4bf1;rgn=div8;view=text;node=50%3A9.0.1.3.7.2.13.6;idno=50;cc=ecfr. Accessed April 2015.

NOAA Fisheries 2013. Status of stocks. Annual Report to Congress on the Status of U.S. fisheries. 8p. accessed at http://www.nmfs.noaa.gov/sfa/fisheries_eco/status_of_fisheries/archive/2013/status_of_stocks_2013_web.pdf

NOAA FishWatch 2014. Alaska Pollock. Accessed at http://www.fishwatch.gov/seafood_profiles/species/pollock/species_pages/alaska_pollock.htm

Oceana 2013. Status and management of the South African small pelagic fishery - August 2013. http://www.oceana.co.za/sites/default/files/Status_and_management_of_the_South_African_small_pelagic_fishery_2013.pdf

Ochi et al. 2014. Summary of utilization of mitigation techniques to reduce seabird bycatch in Japanese small-sized longline vessels. Western and Central Pacific Fisheries Commission. WCPFC-SC10-2014/ EB-WP-07.

Pajaro, M., Macchi,m G.J., Leonarduzzi, E and Hanse, J.E. 2009. Spawning biomass of Argentine anchovy (Engraulis anchoita) from 1996 to 2004 using the Daily Egg Production Method. Journal of the Marine Biological Association of the United Kingdom 89(4): 829–837.

Petersen, S.L., N. Okes, J. Basson, B. Paterson, and A. Cockcroft, (2010), “Ecological Risk Assessment (ERA) Review for the South African West Coast Rock Lobster Fishery”, In S. Petersen, B. Paterson, J. Basson, N. Moroff, J-P. Roux, J. Augustyn, and G. D’Almeida (eds.) (2010) Tracking the Implementation of an Ecosystem Approach to Fisheries in Southern Africa, WWF South Africa Report Series – 2010 / Marine/001.

PFMC (2010). Specifications and management measures for monitored CPS stocks; Agenda item 1.2.c, CPSMT Report 1, November 2010. Pacific Fisheries Management Council, Portland, 13p. http://www.pcouncil.org/wp-content/uploads/I2c_CPSMT_NOV2010BB.pdf

PFMC (2011a). Fishery management plan for US West Coast fisheries for highly migratory species, as amended through amendment 2. Pacific Fisheries Management Council, Portland, July 2011. 106p.

PFMC (2011b). Status of the US West Coast fisheries for highly migratory species through 2010. Stock assessment and fishery evaluation, September 2011. Pacific Fishery Management Council, Portland. 164p.

PFMC (2011c). Status of the Pacific coast coastal pelagic species fishery and recommended acceptable biological catches; stock assessment and fishery evaluation 2011. Pacific Fisheries Management Council, Portland, June 2011. 93p.

Pitcher, T.J. and Preikshot, D. 2001. RAPFISH: a rapid appraisal technique to evaluate the sustainability status of fisheries. Fisheries Research 49, 255–270.

Polovina, J. J., Howell, E., Kobayashi, D.R. & M. P. Seki (2001). The transition zone chlorophyll front, a dynamic global feature defining migration and forage habitat for marine resources. Progress in Oceanography. 49: 469–483.

Pollock DE, Augustyn CJ. 1982. Biology of the rock lobster Palinurus gilchristi with notes on the South African fishery. Fisheries Bulletin of South Africa 16: 57–73.

Popescu, I. and Ogushi, T. 2013. Fisheries in Japan. Directorate General for internal policies European Parliament. 76p.
http://www.europarl.europa.eu/RegData/etudes/note/join/2014/529044/IPOL-PECH_NT%282014%29529044_EN.pdf

Porzio, D. and B. Brady. 2008. Status of the fisheries report: market squid. California Department of Fish and Game: 1-11.

Pramod, G., Pitcher, T., aRojo-Diaz, P. 2006. An Estimation of Compliance of the Fisheries of South Africa with Article 7 (Fisheries Management) of the UN Code of Conduct for Responsible Fishing. In: Tony J Pitcher, Ganapathiraju Pramod, Daniela Kalikoski (Eds). Evaluations of Compliance with the UN Code of Conduct for Responsible Fisheries. Fisheries Centre Research Reports 14(2), Fisheries Centre, University of British Columbia. 29p.

Preikshot, D., Nsiky, E., Pitcher, T., Pauly, D., 1998. An interdisciplinary evaluation of the status and health of African lake fisheries using a rapid appraisal technique. Journal of Fish Biology 53, 381–393.

Prenski, L. Sesar, G & Foucher, C.M. 2014. Surveillance Report. Assessment against MSC principles and criteria for: Argentine Anchovy Fishery (Engraulis anchoita). Organización Internacional Agropecuaria S.A. (OIA) Certificate code: F-OIA-P-0200 (www.oia.com.ar). 33p.

Rademeyer, R.A & Butterworth, D.S., 2010. Proposed Reference Set for the South African hake resource to be used in OMP-2010 testing. 68pp. MCM/2010/FEB/SWG-DEM/05.

Rademeyer, R.A., 2012. 2012 Routine Update of the South African Hake Base Reference Case Assessment. FISHERIES/2012/OCT/SWG-DEM/22.

Roel BA, Cochrane KL, Butterworth DS. 1998. Investigation on the effects of different levels of effort and of the closed season in the jig fishery for chokka squid Loligo vulgaris reynaudii. In Benguela Dynamics. Pillar SC, Moloney CL, Payne AIL, Shillington FA, editors. South African Journal of Marine Science 19: 501–12.

Rose, B., (2011), "Vessel Management Plan to reduce seabird mortality", Responsible Fisheries Alliance unpublished report, 7pp.

SADSTIA 2015. SADSTIA scores a hat trick. South African Deep Sea Trawling Industry Association Newsletter 1. (May 2015).

SAFINA Center 2014. Argentine squid (Ilex argenteus). Accessed at: http://safinacenter.org/documents/2014/08/argentine-squid-full-species-report.pdf

Satria, F., Mahiswara, A. Widodo A., L. Sadiyah, and S. Tampubolon. 2011. Indonesia national report to the Scientific Committee of the Indian Ocean Tuna Commission, 2011. IOTC-2011-SC14-NR10.

Schmidt, C. 2012. Fisheries and Japan: A case of multiple roles. Fisheries Division. OECD. Paris. 18p. http://www.oecd.org/japan/2507622.pdf

SeafoodSource 2011. First anchovy fishery gains MSC certification. http://www.seafoodsource.com/news/environment-sustainability/17284-first-anchovy-fishery-gains-msc-certification).

Seafood Watch, 2006 (updated 2010) Monterey Aquarium. Bigeye tuna Report. 109 p.

Seafood Watch, 2007 (updated 2010) Monterey Aquarium. Albacore tuna Report. 107p.

SFP (Sustainable Fisheries Partnership). 2013. Indonesia Tuna Fishery Improvement Project. Sustainable Fisheries Partnership, Honolulu. Available online http://www.sustainablefish.org/fisheriesimprovement/tuna/indonesia-yellowfin-tuna

Shester, G.G. 2008. Sustainability in small-scale fisheries: an analysis of the ecosystem impacts, fishing behavior and spatial management using participatory research methods. Doctor of Philosophy Degree Thesis. Stanford University, Stanford, CA, USA. September, 2008. 225p.

Sink K.J, Wilkinson S., Atkinson L.J, Sims P.F, Leslie R.W. and Attwood C.G. 2012. The potential impacts of South Africa's demersal hake trawl fishery on benthic habitats: historical perspectives, spatial analyses, current review and potential management actions. Unpublished report, South African National Biodiversity Institute. 75p.

Smith, M., Cochrane, K., & Japp, D, 2013. Review of significant bycatch and "joint product" species in the South African Hake-Directed trawl fishery. Prepared for the South African Deep Sea Trawling Industry Association by Capricorn Fisheries Monitoring. 69pp.
Sofía Solano-Fernández, Colin G. Attwood, Russell Chalmers,

SPC- OFP (Secretariat of the Pacific Community- Oceanic Fisheries Program). 2010. Non-target species interactions with the tuna fisheries of the western and central Pacific Ocean. WCPFC-SC6-2010/EB-IP-8. Available online http://www.wcpfc.int/meetings/2010/6thregular-session-scientific-committee

SPRFMO, 2013a. Report of the 1st Scientific Committee, La Jolla, USA: 21-27 October 2013, Amendment Dec 2013, 45p. http://www.southpacificrfmo.org/assets/Scientific-Committee-1st-2/Report/SC-01-2013-Report-amended-16-Dec-13-a.pdf

SPRFMO, 2013b. CMM 1.01 Conservation and Management Measure for Trachurus murphyi (Annex G), 8p. http://www.southpacificrfmo.org/assets/Commission-Meeting-1st/Report/Annex-G-CMM-1.01-Conservation-and-management-measures-for-Trachurus-murphyi.pdf

SPRFMO, 2013d. Information describing Chilean jack mackerel (Trachurus murphyi) fisheries relating to the South Pacific Regional Fishery Management Organisation, 1st Meeting of the Scientific Committee, La Jolla, United States of America, 21-27 October 2013, SC-01-23, Revisions to Jack Mackerel Species Profile, 42p.
http://www.southpacificrfmo.org/assets/Scientific-Committee-1st-2/Plenary/SC-01-23-Revisions-to-Jack-Mackere-species-profile-a.pdf

SPRFMO, 2014a. Report of 2nd report of the Scientific Committee Meeting. Honolulu, Hawaii, USA, 1-7 October 2014. Annex 04: 2014 jack mackerel stock assessment.
https://www.sprfmo.int/assets/Scientific-Committee-2nd/SC-02-Report/SC-02-Annex-4-Assessment-final3Nov.pdf

SPRFMO, 2014b. Report of 2nd report of the Scientific Committee Meeting. Honolulu, Hawaii, USA, 1-7 October 2014. https://www.sprfmo.int/assets/Scientific-Committee-2nd/SC-02-Report/SC-02-Final-Report-21Oct-accepted.pdf

SPRFMO, 2014c. 2nd Meeting of the Compliance and Technical Committee, Auckland, New Zealand: 30-31 January 2015. CTC-02-02 Assessment of Compliance of Members and CNCPs. https://www.sprfmo.int/assets/Commission-Meeting-3rd/CTC-02/CTC-02-02-Assesement-of-Compliance-of-Members-and-CNCPs.pdf

SPRFMO, 2014d. Second Meeting of the Commission of the South Pacific Regional Fisheries Management Organisation, Manta, Ecuador 27–31 January 2014. Annex K: Proposed Jack Mackerel rebuilding plan. https://www.sprfmo.int/assets/Commission-Meeting-2nd/Comm-02-report/Annex-K-Proposed-Jack-Mackerel-Rebuilding-Plan.pdf

SPRFMO, 2014e. 2nd Meeting of the Scientific Committee Honolulu, Hawaii, USA 1-7 October 2014. SC-02-15 Chile Annual report, Undersecretariat for Fisheries and Aquaculture. https://www.sprfmo.int/assets/Scientific-Committee-2nd/SC-02-Papers/SC-02-15-Chile-Annual-Report.pdf

Stewart, J. & Port-Minner S., 2010. California Market Squid.Seafood Watch Seafood Report.) http://www.montereybayaquarium.org/cr/cr_seafoodwatch/content/media/MBA_SeafoodWatch_CAMarketSquidReport.

Sullivan, M. 2013. Challenges Facing Japan's Marine Fisheries. Scientific American June 2013.

Sustainable Fisheries Partnership. 2014. FishSource Profile for Caribbean spiny lobster - Western Central Atlantic (Country: BR; Gear: FPO;) [FIP: Brazil Lobster, SINDIFRIO] . World Wide Web Electronic Publication http://www.fishsource.com/site/goto_profile_by_uuid/db734d58-433b-11e0-b143-40406781a598 accessed 2015-05-28.

Sustainable Fisheries Partnership. 2014. FishSource Profile for Jumbo flying squid - Eastern Pacific (Country: PE; Gear: LX_jig;) . World Wide Web Electronic Publication http://www.fishsource.com/site/goto_profile_by_uuid/1d244362-1e20-11de-b16d-daf105bfb8c2 accessed 2015-05-29

Sustainable Fisheries Partnership 2015. FishSource Profile for Chilean jack mackerel - Southeast Pacific [FIP: Chilean jack mackerel, CeDePesca] . World Wide Web Electronic Publication http://www.fishsource.com/site/goto_profile_by_uuid/645d48a0-2687-11dd-a4e9-daf105bfb8c2 accessed 2015-04-09.

Sustainable Fisheries Partnership.2015. FishSource Profile for Argentine hake - South of 41°S [FIP: Argentine hake, CeDePesca] . World Wide Web Electronic Publication http://www.fishsource.com/site/goto_profile_by_uuid/644e4760-2687-11dd-a4e9-daf105bfb8c2 accessed 2015-05-28.

Sustainable Fisheries Partnership.2015. FishSource Profile for Argentine hake - North of 41°S [FIP: Argentine-Uruguayan Hake, CeDePesca] . World Wide Web Electronic Publication http://www.fishsource.com/site/goto_profile_by_uuid/64504a56-2687-11dd-a4e9-daf105bfb8c2 accessed 2015-05-28.

Tilney, R.L. & Clement, G. 2009. Deepwater Group Ltd report in response to Condition of Certification 008, MSC Principle 2 Performance Indicators 2.2.3.1 and 2.3.1.1 – Reduction of fur seal interactions on WCS I. 5p.

Thompson, F., Berkenbusch, K. & Abraham, E. (2013). Marine mammal bycatch in New Zealand trawl fisheries, 1995-96 to 2010-11. New Zealand Aquatic Environment and Biodiversity Report No. 105. 77p.

van der Lingen, C.D., Huggett, J.A., 2003. The role of ichthyoplankton surveys in recruitment research and management of South African anchovy and sardine. In: Browman, H.I., Skiftesvik, A.B. (Eds.), The Big Fish Bang. Proceedings of the 26th Annual Larval Fish Conference. Institute of Marine Research, Bergen,
Norway, pp. 303–343.

Vega, V.A. (2010) Programa operativo annual 2010. Prospeccion, evaluacion y manejo de langostas (Panulirus spp.) en las costas de Baja California Sur. La Paz, BCS, 14 de Agosto de 2009

Vega, VA, Trevino, GE, Evans, CG and Zuñiga, PLC (2010) Assessment of the fishery for spiny lobster (Panulirus interruptus) in the central west of the peninsula of Baja California, using biomass dynamic models: benchmarking and management recommendations. Technical Report CRIP La Paz. INAPESCA-SAGARPA. 20 pp.

Walmsley, S.A., R.W. Leslie, and W.H.H. Sauer, (2007b), "Bycatch and discarding in the South African demersal trawl fishery", Fisheries Research, 86:15-30.

Watkins, B.P., S.L. Petersen, and P.G. Ryan. 2008. Interactions between seabirds and deep-water hake trawl gear: an assessment of impacts in South African waters. Animal conservation 11:247-254.

WCPFC (2011). Stock assessment of albacore tuna in the North Pacific Ocean in 2011; report of the Albacore Working Group stock assessment workshop. International Scientific Committee for Tuna and Tuna-like Species in the North Pacific Ocean. CPFC-SC7-2011/SA-WP-10, 9-17 August 2011, Pohnpei, Federated States of Micronesia. 151p.

Widodo, A. 2013. Snapshot of the tuna long line fishery in Indonesia Pacific Ocean FMA-716 and 717. Research Center for Fisheries Management and Conservation.
WWF-SASSI (undated). WWF-SASSI Assessment process guideline document. 3p.

WWF (World Wildlife Fund). 2012. Indonesia Tuna FIP. World Wildlife Fund. Available online https://sites.google.com/site/fisheryimprovementprojects/home/indonesia-tuna-fip

WWF 2013. The Common Wild Capture Fishery Methodology. WCRL (Jasus lalandii) - Pots and Traps - South Africa - 2013 – FINAL. 14p.

Ye, Y. 2011. Assessment methodology. In: Review of the state of world marine fishery resources. FAO Fisheries and Aquaculture Technical Paper 569: 327-334.

Ye, Y. and Cochrane, K. 2011. Global overview of marine fishery resources. In: Review of the state of world marine fishery resources. FAO Fisheries and Aquaculture Technical Paper 569: 3-18.

Young, M. A., R. G. Kvitek, P. J. Iampietro, C. D. Garza, R. Maillet, and R. T. Hanlon. 2011. Seafloor mapping and landscape ecology analyses used to monitor variations in spawning site preference and benthic egg mop abundance for the California market squid (Doryteuthis opalescens). Journal of Experimental Marine Biology and Ecology 407: 226-233.

Zeidberg, L., W. Hamner, N. Nezlin, and A. Henry. 2006. The fishery for California market squid (Loligo opalescens) (Cephalopoda:Myopsida), from 1981 through 2003. Fishery Bulletin 104: 46-59.