CONVENTION ON INTERNATIONAL TRADE IN ENDANGERED SPECIES
OF WILD FAUNA AND FLORA

Twenty-sixth meeting of the Animals Committee
Geneva (Switzerland), 15-20 March 2012 and Dublin (Ireland), 22-24 March 2012

REPORT ON A METHOD TO IDENTIFY HIGH RISK COMMERCIALLY-EXPLOITED AQUATIC ORGANISMS IN TRADE AND AN ANALYSIS OF THE POTENTIAL APPLICATION OF MEAS

1. This information document has been submitted by the United Kingdom in relation to agenda item 14[*].

2. The attached report describes work commissioned by the UK Scientific Authority (Fauna) from TRAFFIC International and which was referred to in the European Union submission (AC26 Doc. 16.2 Annex European Union p. 6) in response to Notification 2011/049.

3. The work sought to identify, by a process of risk assessment, those commercially exploited aquatic organisms, including sharks, at greatest potential risk from over-exploitation and which might then be subject to further scrutiny to determine if they would benefit from measures under CITES or the Convention on Migratory Species to reduce those risks. The work might thus help to inform the work of the Animals Committee under Res. Conf. 12.6 (Rev. CoP15) with respect to sharks.

4. The report was examined by a 2-day peer review workshop by invited experts which took place in Aberdeen (United Kingdom) from 26-27 September 2011. The report of this peer review workshop is provided as an Addendum attached to the report. Both reports are available at: http://jncc.defra.gov.uk/page-6120.

5. Based on recommendations made at the peer review workshop on ways to improve the method and to apply it further, additional work was commissioned from TRAFFIC to assess the vulnerability of a single taxonomic group, namely sharks. The draft report of this work is provided in AC26 Inf. 9.

[*] *The geographical designations employed in this document do not imply the expression of any opinion whatsoever on the part of the CITES Secretariat or the United Nations Environment Programme concerning the legal status of any country, territory, or area, or concerning the delimitation of its frontiers or boundaries. The responsibility for the contents of the document rests exclusively with its author.*

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Fish and Multilateral Environmental Agreements (MEAs): developing a method to identify high risk commercially-exploited aquatic organisms in trade and an analysis of the potential application of MEAs

Sant, G., Goodman, G., Crook, V., Lack, M. & Oldfield, T.E.E

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For further information please contact:

Joint Nature Conservation Committee
Monkstone House
City Road
Peterborough PE1 1JY

Corresponding author
Thomasina Oldfield
TRAFFIC International
219a Huntingdon Road
Cambridge, UK, CB3 0DL
Thomasina.Oldfield@traffic.org

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Furthermore, we would like to thank the experts that provided species and value information, many of them members of the IUCN Species Survival Commission Specialist Groups, as well as SeaLifeBase and other scientists and experts who have volunteered their time and expertise to this process.

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Foreword

The following report was commissioned by JNCC to explore means by which a strategic overview could be taken of the risks posed to aquatic organisms (fish and invertebrates) by commercial exploitation for international trade. In doing so, it might then be possible to identify those species at greatest potential risk from over-exploitation and to seek measures to reduce those risks, involving multi-lateral environmental agreements such as CITES or CMS where appropriate.

In developing this method, the authors identified a number of practical difficulties in applying the approach taken. As a result, an expert workshop was held to provide peer review of the method and to identify ways in which it might be improved. The outcome of this workshop, with its various recommendations, forms an addendum to this report; the two should be read in combination.

In order to take forward the workshop recommendations, a further application of the method, with refinements, to a single taxonomic group (namely sharks) has been commissioned from TRAFFIC. The outcome of this will be reported separately.

Vin Fleming
February 2012

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Executive summary

Over-exploitation of fish species has been identified as the dominant direct driver of biodiversity loss in the marine environment. Many commercially exploited aquatic organisms are subject to harvest levels that are in excess of what is likely to be sustainable. In 2008, 32% of fish stocks were considered to be over-exploited, depleted or recovering, an increase from around 10% in the 1970s. Fishing is conducted in a range of management environments. Some fish stocks/species remain completely unmanaged, others are managed by provincial or national governments whilst yet others are managed through bilateral agreements or through multilateral agreements for migratory species implemented through regional fisheries management organisations (RFMOs). However, the status of stocks indicates that, globally, the governance and management of fisheries is failing to deliver sustainable fish stocks. While there are examples of effective national management of target fish stocks and, to a lesser extent, non-target stocks, the experience at the international level, through RFMOs, suggests very limited success in managing fish stocks.

The failure of fisheries management alone to protect fish stocks has led to increasing calls for the application of multilateral environmental agreements (MEAs), such as the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES) and the Convention on the Conservation of Migratory Species of Wild Animals (CMS), to commercially exploited fish species. As a result, a number of these species have been proposed for listing in the Appendices of these two MEAs. Although some species have now been listed, there has been strong opposition and contention regarding proposals to list commercially exploited aquatic species in the CITES Appendices and many have been unsuccessful.

It is in this context that the Joint Nature Conservation Committee (JNCC) identified[1] the need for a systematic review of commercially exploited fish[2] species in order to identify those species for which the application of CITES or CMS, as complementary measures to fisheries management, might make a tangible difference to their conservation and sustainable use. The project did not, however, aim to assess whether the highest risk species identified met the specific criteria for listing within the Appendices to CITES or CMS, nor was it intended to identify a 'shopping list' of candidates for listing. Rather, it was intended that this project should help to inform thinking on whether, or how, both Conventions might better complement fisheries management and fish conservation.

TRAFFIC was contracted to undertake the review based on an approach developed by an FAO appraisal of the suitability of the CITES criteria for listing commercially-exploited aquatic species. That approach suggests that risks faced by aquatic species can be characterised in terms of:

- vulnerability: related to the inability (for bio-ecological reasons) of a species to sustain the levels of exploitation that it may be subjected to, this factor could also be called 'bio-ecological risk'.
- value: related to the profitability of the species' exploitation, this factor could also be called 'economic risk'.
- violability: related to the extent to which conventional management measures may be circumvented, this factor could also be called 'compliance risk'.

The results of TRAFFIC's application of this approach are presented in this report and its associated database.

[1] http://www.jncc.gov.uk/pdf/COMM_07D08.pdf

[2] "Fish' is used here to refer to fish and invertebrate species harvested commercially in marine waters and/or large freshwater bodies. This definition excludes aquatic amphibians, reptiles, birds, mammals and plants.

This study has provided valuable insights into the range and extent of trade in fish species. In doing so, it has identified relevant data sources and developed approaches for dealing with many of the gaps and inconsistencies in the data available.

From FAO catch data identifying approximately 1,600 taxa, 505 commercially traded and/or migratory fish species were selected through the application of various criteria. Of the 505 selected species, 44% were categorized as migratory and 18% were either listed or had been proposed for listing in CITES and/or listed in Appendix I and/or II of CMS.

These 505 species were assessed for vulnerability and value based on a set of core characteristics (see Table 1). A database was developed to store relevant information and to help score for vulnerability, value and violability.

Table 1: Variables used in assessing risk

Vulnerability	Value	Violability
Age at maturity—minimum (years)	Ex-vessel/landing prices	Scale of the fishery
Size at maturity—minimum (cm)	Expert judgement on species with high value commodities	Target or non-target catch
Maximum age/ longevity (years)		Fishery location
Average size—maximum (cm)		Management jurisdiction
Reproductive Strategy		Stock assessment
Fecundity (max litter size or no. of eggs)		harvest-related measures
Trophic level		Trade-related measures
		MCS measures

Based on the scoring of high vulnerability and value, a sub-set of 109 species were then assessed for violability. The analysis in this study clearly points to the need to assess violability of species at the stock level rather than the species level as different stocks are subject to different management jurisdictions and regimes.

The percentage of species assessed for vulnerability, value and violability scoring high, medium and low is provided in Table 2.

Table 2. Species by category (%)

Score	Vulnerability (n=505)	Value (n=505)	Violability (n=109)
Low	41	59	14[1]
Medium	32	16	28
High	24	18	33[2]
No score	3	6	25

Note: [1] corresponds to very low and low and [2] very high and high.

Based on the vulnerability, value and violability scores, 54 species were considered further; 34 species at high risk of over-exploitation, 12 species at potentially high risk and eight with high violability scores. Those identified included: finfish and invertebrates, freshwater and marine species.

Fifty-two percent of these high-scoring species were considered migratory and 43% were listed by one or both of CITES and CMS.

Sharks were heavily represented in the highest risk group, comprising 17 of the 54 species (31%). This is not surprising given they have common life history characteristics that make them vulnerable to over-exploitation and generally shark fins have high value. In addition, there is acknowledged paucity of management for these species globally.

A number of false positives and, potentially false negatives have emerged. However, the list of "highest risk" species does provide guidance on those species potentially at highest risk and hence those to prioritize in the future when considering management strategies and sustainability measures.

Regarding the applicability of CITES and CMS to the 54 species, the following conclusions were drawn:

- CITES could provide benefits to southern bluefin tuna *Thunnus maccoyii*, Atlantic bluefin tuna *Thunnus thynnus*, Patagonian toothfish *Dissostichus eleginoides*, leafscale gulper shark *Centrophorus squamosus*, gulper shark *Centrophorus granulosus*, dusky shark *Carcharhinus obscurus*, copper shark *Carcharhinus brachyurus*, thresher shark *Alopias vulpinus*, porbeagle *Lamna nasus* and scalloped hammerhead shark *Sphyrna lewini*;
- further analysis of trade is required to determine the applicability of CITES to bluntnose sixgill shark *Hexanchus griseus*, longfin mako shark *Isurus paucus* and blue marlin *Makaira nigricans*;
- CMS could provide benefits to southern bluefin tuna, blue marlin and all the migratory shark species in the high-risk groups; and
- CMS could help to address harvest for national consumption, by-catch as well as other non-trade related threats for migratory species and may have benefits for species such as largetooth/freshwater sawfish *Pristis microdon*, narrowsnout sawfish *Pristis zijsron*, pangasid catfish *Pangasius sanitwongsei* and aba *Gymnarchus niloticus*.

The application of risk-based approaches to fish species has, until now, been restricted to the analysis of the risk posed by a fishery to particular species in, or associated with, that fishery. The development of an appropriate methodology to undertake those analyses has required considerable time and resources and will continue to evolve. The scope of this project is significantly broader, given that it deals with the impacts of all fisheries on species throughout their global range, as well as introducing the impact of trade on the species. It is not surprising, therefore, that this first iteration of the methodology has identified a range of issues that require further refinement and analysis, which are discussed and suggestions for improvement made.

Despite data gaps and the potential to refine this methodology further, it is clear that, where data are available, an analysis such as this can provide useful guidance to identification of the relative risk-level of species in trade and can prioritise those species for which additional consideration and research would be useful to determine the benefits of MEA measures.

1 Introduction

1.1 Background

Over-exploitation of fish[3] species has been identified as the dominant direct driver of biodiversity loss in the marine environment (Millennium Ecosystem Assessment 2005). Trade in fish and fish products is a major driver of this biodiversity loss, since these products are highly traded commodities. In 2008, 39% of the total global production of fish (liveweight equivalent) entered international trade and the annual rate of growth in fishery trade since the mid-1970s has averaged 8.3% in value terms. In 2008, total world exports of fish and fish products reached a record value of USD102.0 billion, an increase of more than 80% from 2000 (FAO 2010a). World fish imports rose 95% between 1998 and 2008, reaching the new record of more than USD107.1 billion in 2008 (FAO 2010a).

Many commercially exploited aquatic organisms are subject to harvest levels that are in excess of what is likely to be sustainable. In 2008, 32% of fish stocks were considered to be over-exploited, depleted or recovering, an increase from around 10% in the 1970s. In contrast, the proportion of under-exploited or moderately exploited stocks has declined from 40% to 15% over the same period and the proportion of fully exploited fish stocks remained stable at around 50% (FAO 2010a). This increasing trend in the percentage of over-exploited, depleted and recovering stocks and the decreasing trend in underexploited and moderately exploited stocks is cause for concern.

Fishing is conducted in a range of management environments. Some fish stocks/species remain completely unmanaged, others are managed by provincial or national governments, and yet others are managed through bilateral agreements for stocks that straddle exclusive economic zones (EEZs), or EEZs and high seas, or through multilateral agreements for migratory species implemented through regional fisheries management organisations (RFMOs). However, the status of stocks indicates that, globally, the governance and management of fisheries was insufficiently effective, in many cases, to achieve sustainable fish stocks. While there are examples of effective national management of target fish stocks and, to a lesser extent, non-target stocks, the experience at the international level, through RFMOs suggests very limited success in managing fish stocks.

The failure of fisheries management and governance alone to protect fish stocks has led to increasing calls for the application of multilateral environmental agreements (MEAs), such as the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES) and the Convention on the Conservation of Migratory Species of Wild Animals (CMS), to marine species. As a result, a number of marine species have been proposed for listing in the Appendices of these two MEAs. Although some species have now been listed, there has been strong opposition to CITES listing proposals and many of these have been unsuccessful.

It is in this context that the Joint Nature Conservation Committee (JNCC) identified the need[4] for a systematic review of commercially exploited fish species in order to identify those species for which the application of CITES or CMS may make a tangible difference to conservation and sustainable use. TRAFFIC was contracted to undertake such a review, the results of which are presented in this report and its associated database.

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[3] "Fish' is used here to refer to fish and invertebrate species harvested commercially in marine waters and/or large freshwater bodies. This definition excludes aquatic amphibians, reptiles, birds, mammals and plants.

[4] See http://www.jncc.gov.uk/pdf/COMM_07D08.pdf

1.2 Aims and objectives

This project aimed to:

1. identify the range of commercially-exploited fish and aquatic invertebrate species in international trade and those which are migratory;
2. determine by application of vulnerability, value and violability criteria, the degree of risk of use incompatible with their survival, driven by trade, to which these species might be subject;
3. analyse where management by RFMOs and other national/international regulations or mechanisms is unlikely to provide sufficient safeguards to prevent unsustainable use or achievement of favourable conservation status (and where regional co-operation is likely to be of benefit);
4. identify the characteristics of those species/groups which emerge as highest risk and for which, as a consequence, involvement by MEAs might make a tangible difference to their conservation and sustainable use by complementing, or encouraging, management of fisheries; and
5. provide recommendations on how the conservation and management of these groups of species might be furthered through MEAs or other means.

The project did not, however, aim to assess whether the highest risk species identified met the criteria for listing within the Appendices to CITES or CMS, which have their own specific criteria for listing nor was it intended to identify a ‘shopping list’ of candidates for listing. Rather, it was intended that this project helped to inform thinking as to if, or how, both Conventions might better complement fisheries management and fish conservation (and thus contribute to global food security and conserving ecosystem services) and to consider where trade regulation or other measures by these MEAs might assist other bodies to meet their fishery management goals.

The framework developed by the project includes a database and ranking systems. It provides an ongoing mechanism for assessing risk and identifying potential benefits from MEAs through the updating of information on variables such as value and management changes and as more biological information becomes available.

2 Approach

The value, vulnerability, violability approach applied through this project is based on the findings of an FAO appraisal of the suitability of the CITES criteria for listing commercially-exploited aquatic species (FAO 2000). That appraisal suggested that the risks faced by aquatic species could be characterised in terms of:

- vulnerability: related to the inability (for bio-ecological reasons) of a species to sustain the levels of exploitation that it may be subjected to, this factor could also be called 'bio-ecological risk'.
- value: related to the profitability of the species' exploitation, this factor could also be called 'economic risk'.
- violability: related to the extent to which conventional management measures may be circumvented, this factor could also be called 'compliance risk'.

Risk-based approaches to fisheries management and catch have become more widely adopted in recent years. For example, the Australian Commonwealth Scientific and Industrial Research Organisation (CSIRO) has developed an *Ecological Risk Assessment for the Effects of Fishing*[5] (Hobday *et al.* 2007*),* which has been used extensively in Australian fisheries. This is discussed further in Section 4 on vulnerability. However, this study is the first attempt to apply a risk-based approach to fisheries trade. As well as identifying species, and the characteristics that may place those species at risk from trade, this project provides a framework for conducting such analyses in future. Over time, the methodology may be subject to further refinement and should be adapted appropriately by each user.

The development of a database has been the centrepiece of this project and contains the information collected in order to allocate scores for value, vulnerability and violability for as many species as possible. The following stages are described in further detail through the following sections:

- identification of commercially exploited aquatic species
- identification of migratory behaviour
- selection of a subset of commercially exploited species that are or are likely to be in international trade and/or migratory
- collation of life history information to be used in scoring for vulnerability
- scoring of vulnerability
- estimation of unit price for species (USD/kg) and identification of species with high value for specific commodities
- scoring of value
- selection of a subset of high-risk species, on the basis of vulnerability and value, for violability assessment
- for species selected for violability analysis, collation of information on fisheries characteristics, management and enforcement
- scoring of violability

On the basis of all the information collected in the steps above, the species identified as highest risk in terms of vulnerability, value and violability were identified. It was then considered whether the highest-risk species would benefit from MEA measures and whether they exhibited common characteristics indicative of this.

[5] See http://www.csiro.au/science/fisheries-ecological-risk-assessment--ci_pageNo-3.html

3 Selection of commercially exploited species

3.1 Trade in fish products

Trade in 'fish' products is very complex and tracing the origin of the products in trade is difficult. Some of the characteristics and challenges of monitoring the fish trade that need to be recognised in interpreting trade-based data are discussed below.

Most fish products entering international trade are not identified by species but traded under generic names, such as names of groups of species, e.g. sharks, sea cucumbers or clams. However, some high-value products are identified by species since there is sufficient market incentive for catchers and exporters to ensure that the species is accurately identified in trade in order to attract the premium price it commands.

The current version of the Harmonized Commodity Description and Coding System (the Harmonized System (HS)) does not provide adequately for the specification of fish and fishery products by species or product type. However, as a result of an initiative by FAO, a revised version of the HS will enter into force on 1 January 2012 (FAO 2010a). The revised HS codes for fish and fishery products will improve the quality and precision of fish trade coverage through an improved specification for species and product form. FAO notes that:

- the classification has been restructured according to main groups of species of similar biological characteristics;
- around 190 amendments have been implemented and about 90 new commodities (species by different product form) have been introduced;
- the choice of the added species was based on their present and future economic importance as well as on the monitoring of potentially endangered species.
- species introduced include turbot *Psetta maxima*, hake, seabass, seabream, Alaska Pollock *Theragra chalcogramma*, cobia *Rachycentron canadum*, jack and horse mackerel, rays and skates, Norway lobster *Nephrops norvegicus*, coldwater shrimps, clams, cockles, arkshells, abalone *Haliotis* spp., sea urchin, sea cucumber and jellyfish; and
- several more splits by product form for several species have also been introduced, in particular for meat and fillets; for shark fins in cured form; for caviar, as distinct from substitutes; for molluscs, as distinct from other aquatic invertebrates; and for seaweeds for human consumption, as distinct from that for other purposes (FAO 2010a).

Trade data do not distinguish between products derived from different stocks of the same species. If one stock of a multi-stock species is poorly managed, or subject to high levels of illegal, unreported and unregulated (IUU) fishing, and is therefore subject to particular management regimes or is listed in CITES or CMS, trade data will be of little assistance in monitoring the impacts of those measures. Nor do they distinguish between fish products derived from wild fisheries and those sourced from aquaculture, fish ranching operations or wild capture fisheries. For these reasons it is difficult, on a species basis, to compare fish catch data with fish trade data and it is possible that there may be considerable differential impacts on a species from products derived from one or the other of these sources.

Fish species enter international trade in a wide variety of product forms, such as dried, fresh, frozen, oil, meat, etc. This, together with the fact that multiple products can be derived from a single individual of a species, creates difficulties in using trade data as a proxy for catch. Consistent and accurate, species-specific and product-specific conversion factors are required, but are often unavailable.

Many fish species, even in their whole form, can be difficult to identify accurately to species level. Even experienced fishers have difficulties in correctly identifying catch to species level. This issue is compounded once fish are subject to processing. For example, removal of the head or skin of a fish can remove many species-defining characteristics. When processed to fillets or other forms, visual identification of species type is very problematic for fisheries and/or customs officers. Further, many fish products or consignments of fish are in fact mixtures of species rather than a single species.

Increasingly, fish products enter international trade more than once. For example, a country may export headed and gutted finfish to another country, which then processes that product into fillets or any number of other product forms and exports the resultant product. Such 'transformed' products are not identified in international trade data as re-exports and therefore double counting of products in trade can occur.

3.2 Identifying commercially exploited species and/or species in international trade

Because of the difficulties with using trade data described above, the first stage of the process used in the present study to identify 'commercially exploited aquatic species' involved looking at FAO 'Capture Production' data, which do not include aquaculture production. These data are freely accessible and, of the available marine and freshwater species lists, provide a relatively detailed taxa list, much of which is to the species level. Data were extracted from the FAO FISHSTAT database[6] on FAO Capture Production data from 2000-2008 (2009 data were not available at the time) and the FAO 'Divisions' were used in order to group species into broad categories, including freshwater, marine, diadromous, crustaceans, molluscs and 'other'. Average annual catch (tonnes) between 2000 and 2008 was calculated for species and higher taxonomic/commodity groupings (after this point, referred to as the 'FAO catch list'). Where FAO had grouped catch data for two species together (into a single record), an average value for each species was calculated. This value was then added to the overall catch of a single species where relevant. For example, catch data were given for frigate tuna *Auxis thazard* and bullet tuna *Auxis rochei* both together and separately. Where catch data were given at larger taxonomic group level, data were not manipulated to be included under specific species names, as this was regarded to be too unreliable.

The FAO catch list was used to provide an initial list of taxa (including more than 1,600 taxa). However, even though a large proportion of catch data was available at the species level, a considerable number of the overall catch was reported at genus, family and other higher taxonomic levels, including, very generally, e.g. 'sea cucumbers', 'cockles' or 'crustaceans'. It was, therefore, necessary to select at both species and higher taxonomic level to ensure that there was the best possible cross section of all commercially exploited species in the subsequent selection. Criteria for selection are described in section 3.4.

From the FAO catch list, species or taxa with high levels of catch (>10,000/t/yr) were assumed to be in international trade. In addition, data were requested from the US Fish & Wildlife Service's trade database (LEMIS) to identify species and genera that were imported and exported by the USA, 2000-2008. The CITES trade database was investigated for trade in aquatic species that listed in the CITES Appendices. In addition, species that had been proposed for listing in the past were also assumed to be in international trade and used in the selection criteria (see section 3.4).

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[6] http://www.fao.org/fishery/statistics/global-capture-production/en

3.3 Identifying migratory species

Species identified in the FAO catch list were coded in the database for migratory behaviour resulting in 27% of species in the FAO catch list being identified as migratory. For this coding, a variety of sources were used, including CMS, the Global Register of Migratory Species (GROMS)[7] and the United Nations Convention on the Law of the Sea (UNCLOS). These sources use a number of different definitions for the term 'migratory' (see section 6.2.1i for further discussion). In this instance, no one definition was followed, as there was no opportunity to examine these issues in greater depth. Instead, by using a large number of resources to gather information on this issue, and by recording from which resource/s information was obtained, the opportunity is provided to re-visit or revise interpretation at a later date.

Additional information collated
FAO trade data (annual amounts calculated in tonnes) and International Union for Conservation of Nature (IUCN) Red List status, where available, were also included (see "FAO catch data with selection information") in this initial list of over 1,600 species taken from FAO catch data.

3.4 Selecting a subset of species

It was necessary to select a subset of species from the FAO catch list which would be assessed for vulnerability value and violability.

The aims of this subset selection were to:

- reduce the species list to a more manageable number;
- identify species most highly commercially traded;
- identify species potentially threatened as a result of commercial exploitation (even if at low levels);
- identify a number of species subject to some trade and which are migratory; and
- obtain a balance in terms of number of commercially exploited marine fish, freshwater fish, diadromous fish, crustaceans, molluscs and other species (including invertebrates, such as coral).

Table 3. Data collected for species selection criteria

Used to derive information on:	**Source**
Average annual catch levels	FAO capture production data
Species in international trade	LEMIS (where recorded in LEMIS data 2000-2008) FAO catch data (>10,000/t/yr) CITES trade data
Threat status	IUCN Red List
CITES listing or proposal for listing	CITES
Migratory behaviour	CMS (to species or higher level) GROMS UNCLOS

Criteria were devised to select species from the initial FAO catch list using the information outlined in Table 3. Criteria (A-F below) were set to select relevant species as outlined in the "aims of the subset selection". Species or higher taxonomic groups that met any of the

[7] Available at: http://www.groms.de/

criteria below were selected for the next stage of the project, noting that a number of species met several of the specified criteria:

A. Taxa classified as migratory (through GROMS, CMS and/or UNCLOS) **AND** listed on the Red List as threatened (Critically Endangered (CR), Endangered (EN), Vulnerable (VU)) or Near Threatened (NT) or NT equivalent)
B. Taxa classified as migratory (as above) **AND** with an average annual catch level of over 10,000 t according to FAO catch data
C. Taxa classified as in international trade (either listed in FAO international trade data or in LEMIS data) **AND** in the IUCN Red List (as above)
D. Taxa classified as in international trade (as above) **AND** with an average annual catch level of over 10,000 t according to FAO catch data
E. All species in or proposed for listing in the CITES Appendices in the FAO capture production list to species level. (A subset of species was later selected which were not on the FAO catch list but were listed or proposed for CITES, see discussion in section 3.4.1.)
F. Any species identified by experts as highly traded or highly vulnerable were also included, where deemed appropriate

Criteria A and C were based, in part, on species IUCN Red List status. This was to ensure species which may be threatened by commercial exploitation even where trade is at low levels, were not excluded. Important to note is that, although the IUCN Red List assessments have recently been updated for many aquatic species, there are still a large number of species which have not been assessed at all or for which assessments are out of date.

For groups which were selected from the FAO catch list using criteria A to F but which were listed at higher taxonomic levels, i.e. order, family, genera or higher, an additional selection process was formulated to identify those species within these taxonomic groups which were commercially exploited, and then to establish if it was necessary to add any species from this group to the selection, for example, in cases where a family was not represented to species level in the selection list. This was done using the approach outlined below:

3.4.1 Selecting species from higher taxonomic groups which were selected from the FAO catch list

- For each higher taxonomic group selected using criteria A-F, the number of species contained within the group was identified. For groups considered under-represented in the selection list, given the number of species within the said genus, family or higher group the LEMIS trade database and the FAO catch data were revisited to investigate which species within the higher taxonomic groups were commercially exploited. Where trade was at reasonable levels and the taxonomic group was under-represented, the species was included.

- If, through using the LEMIS database and the FAO catch data, no species/very low trade was found for species within the higher taxonomic groups then a number of other sources were consulted including: CITES Appendices and CITES listing proposals, IUCN Red List, GROMS and the CITES trade database. Where necessary, further literature research and expert consultation was carried out.

    - When using CITES listing as a criterion to select additional species from larger taxonomic groups, every effort was made to select the most relevant species (i.e. highly traded species and species listed due to potential over-exploitation as opposed to look-alike reasons) and to ensure the selection was representative. However, where species were selected randomly, this is not guaranteed.

- Corals and seahorses took special consideration due to the difficulty of identifying trade at the species level. For both groups, the total number of species within each group was considered, in order to try and get a representative spread of commercially exploited species. For seahorses, CITES trade data, LEMIS data and IUCN Red List status were used to determine which species were included. For corals, species which were CITES-listed and had high levels of trade according to the CITES trade database were selected; then, for any under-represented groups, species which had reasonable levels of trade and were classified as threatened in the IUCN Red List were selected and, lastly, any species listed as EN or CR in the IUCN Red List and whose genus was not represented through other selection criteria, were added.

- Additional species were added where advised by experts or where literature research revealed seemingly important commercially exploited species.

Using the methods described above, additional species were selected for under-represented genera or family groups following these simple rules, depending on the total number of species contained within the groups:

1. For genera/families with a total of one to 10 species, a minimum of one species was selected
2. For genera/families with a total of 11-50 species, a minimum of two species were selected
3. For genera/families with a total of >50 species a minimum of three species were selected

Through the selection process described in the stages above, 505 species were selected. Of these 505 species, 44% were categorized as migratory and 18% were either listed or have been proposed for listing in CITES and/or listed in Appendix I or II of CMS. A list of these 505 species can be found in the "summary" worksheet of the database.

Table 4. Number and percentage of species selected for analyses within each FAO Division

FAO Division	Number	Percentage
Crustaceans	24	5
Diadromous	32	7
Molluscs	46	9
Freshwater	56	11
Aquatic nei [1] and Miscellaneous	63	12
Marine fishes	284	56
Total	505	100%

1. 'nei': not elsewhere included

4 Vulnerability

4.1 Introduction

Life history characteristics or traits of species are often good indicators of how a species is likely to cope with external pressures such as climate change, natural disasters, exposure to new diseases and harvesting. There have been a number of attempts to investigate and predict species 'coping' strategies based on their biological characteristics (e.g. see Fagan *et al* 2001, Jennings *et al* 1998, Purvis *et al* 2000). These characteristics may include reproductive strategy, size, longevity, diet, age at maturity and many more. Many of these characteristics are impacted by external stimuli and some species will be more adaptable than others. Although it is not always possible to predict 'coping strategies', it is possible to investigate which species are likely to be the most vulnerable as a result of their biological traits, i.e. species with a long life history are considered less well equipped to deal with sustained harvesting pressure.

The method used in this project for assessing the vulnerability of species to fishing was based on the *Ecological Risk Assessment for Effects of Fishing* developed by CSIRO for the Australian Fisheries Management Authority. CSIRO's risk assessment is a multi-level approach for assessing the impact of fisheries, including on target and non-target species and ecosystems (see Hobday *et al* 2007 for further details).

Part of this risk assessment includes 1) assessing the extent of impact from a specific fishery, e.g. the likelihood of being impacted by the fishery (Susceptibility) and 2) the potential of each component to recover from that impact (Productivity). These two components make up the Productivity Susceptibility Analysis (PSA). The assessment of productivity combines measures of:

- average age at maturity
- average size at maturity
- average maximum age
- average maximum size
- fecundity
- reproductive strategy
- trophic level

CSIRO's approach to evaluating risk for fisheries has been adopted and modified by other agencies. For instance the US National Oceanic and Atmospheric Administration (NOAA) has customized the Productivity-Susceptibility Analysis (PSA) specifically to assess the vulnerability of US fish stocks. It also uses a semi-quantitative and rapid risk assessment tool that relies on the life history characteristics of a stock (i.e. productivity) and its susceptibility to the fishery in question. NOAA's productivity variables used are:

- population growth (*r*)
- maximum age
- maximum size
- growth coefficient (*k*)
- natural mortality (*M*)
- fecundity
- breeding strategy
- recruitment pattern
- age at maturity
- mean trophic level.

NOAA's evaluation of susceptibility includes analysis of each fishery for;

- 'catchability' and management based on aerial overlap
- geographic concentration
- vertical overlap
- seasonal migrations, schooling, aggregation, and other behaviours,
- morphology affecting capture
- desirability/value of the fishery.

Due to the availability of data and an already-developed and tested approach, assessment of vulnerability in this study was based on CSIRO's productivity assessment.

4.2 Collating information on life history to determine vulnerability

For this project, information on the productivity measures used by CSIRO for each of the selected species was collected. The following biological information (referred to as biological characteristics) was collected for all species where the data were accessible:

a. Average age at maturity (minimum)
b. Average size at maturity (minimum)
c. Average age/longevity (maximum)
d. Average size (maximum)
e. Fecundity (maximum litter size, or number of eggs if this not available)
f. Reproductive strategy (see Table 6)
g. Trophic level (position of the species within the larger fish community)

Averages for biological variables a-d were calculated where information was available for male, female and unsexed/unknown specimens. Where these data were not available, the best data found were used. In some cases, such as with average size at maturity (where males and females often mature at very different rates), this could have made a significant difference to overall score. However, due to the relatively wide categories used for determining levels of vulnerability as high, medium or low, it was assumed that, in the main, it would not result in a different vulnerability score for the species. Moreover, where no maximum or minimum value could be identified in the literature, any relevant values found were averaged and used.

A number of resources were consulted when collecting the biological data (see reference database, "Vulnerability" worksheet). Both CSIRO and FishBase provided parts of their databases for use to enable extraction of the relevant data. Data provided by CSIRO were the primary resource used to complete the biological characteristic information. This was due to the fact that CSIRO gathers information both from existing datasets, such as FishBase, and collects vast amounts of information through literature and other means, making it a relatively complete data set. While it was not possible to check each data point referenced within CSIRO, where data were noticeably different from other sources, an attempt was made to check a third source in order to use the most accurate information. Where CSIRO data were not available, data from FishBase were used. The one exception to the rule was for trophic level, for which FishBase was used as the primary data source. In this case, CSIRO data were only used when no FishBase data were available, due to the apparent discrepancies between the two databases, as CSIRO's data for trophic level are specifically adjusted for subpopulations occurring in Australia.

Where data were missing, additional sources of information were consulted. For invertebrates, data on maximum size were also provided by SeaLifeBase[8]. The IUCN Species Information Service (SIS), the database used for managing the IUCN Red List, was

[8] Available at: http://www.sealifebase.org/

consulted where data gaps existed and the species was known to be on the IUCN Red List or assessed, including where assessments were incomplete or not yet published. Spot checks on other IUCN Red Listed species were performed to ensure that data from different resources were comparable. Finally, literature research and expert consultation were conducted for species where data were significantly lacking. In particular, the FAO website[9] and species factsheets and experts from IUCN Species Survival Commission Specialist Groups were consulted. Where experts suggested alternative figures, amendments to the data were made and suggestions for additional species to be added to the assessment were also taken on board.

4.3 Scoring for vulnerability

CSIRO uses the characteristics outlined in section 4.2 to investigate productivity—the ability to recover from impact—which is effectively the opposite of vulnerability. Each biological characteristic for each species was scored using the cut offs specified in Tables 5 and 6 with a score of one for low vulnerability (high productivity), two for medium vulnerability (medium productivity) or three for high vulnerability (low productivity).

Largely, CSIRO's cut-off values for high, medium and low categories of productivity were replicated to assess vulnerability for the species. However, in the case of trophic level, cut-off values used by NOAA were considered more appropriate, as CSIRO cut-off values are adjusted for Australian sub-populations.

Table 5. Scoring values for biological traits

Vulnerability score (1=low, 2=medium, 3=high)	Age at maturity—minimum (years)	Size at maturity—minimum (cm)	Average age/longevity—maximum (years)	Average size—maximum (cm)	Fecundity (max. litter size or no. of eggs)	Trophic level
1	<5	<40	<10	<100	>2000	<2.5
2	5-15	40-200	10-25	100-300	100-2000	2.5-3.5
3	>15	>200	>25	>300	<100	>3.5

(See Table 6 for reproductive strategy)

Table 6. Reproductive strategy types and scoring

Reproductive code	Reproductive strategy	Vulnerability score (1=low, 2=medium, 3=high)
LB	Live bearers	3
DS	Demersal spawners	2
BG	Brood guarders/guard young	2
BS	Broadcast spawners	1
NG	Non-guarders	1
AS	Asexual	1

For many aquatic species, the biological data required are simply not available at present. Uncertainty has been dealt with differently by CSIRO and NOAA: the former uses a precautionary approach and allocates high-risk scores where data are missing; the latter incorporates a separate "Data Quality Index". Due to the large number of gaps in data compiled for this project, using the precautionary approach was not considered appropriate. Instead, missing vulnerability scores for each biological trait were excluded from the calculations and an average score was calculated. A score has been allocated to each species for the 'reliability' of its vulnerability score, based on the amount of data, i.e. the

[9] http://www.fao.org/fishery/en

number of biological traits for which information was found (as detailed in Table 7), although this score has not been reflected in the final selection of high-risk species. Potentially, information for any one of the missing traits could alter the vulnerability categorisation. This issue would require further consideration in any future development of this approach to assessing risk.

Table 7. Reliability of vulnerability scores

Number of biological traits for which information found (of 7)	Reliability	Number of species
1-2	Low	83
3-5	Medium	164
6-7	High	241

4.4 Results

Data and scoring for vulnerability can be found in the "Vulnerability" worksheet in the database. A list of species classified as having either medium or high vulnerability can also be found in Appendix 1.

Based on average scores for the seven biological traits assessed: 206 species were assessed as having low vulnerability (scoring between1-1.5), 160 as having medium vulnerability (scoring between >1.5 to <2) and 122 as having high vulnerability (scoring 2 or more). Of all the species assessed, just 17 had no vulnerability score, due to complete lack of data availability. However, for those where at least some data were available, 83% were regarded as having high (49%) or medium (34%) reliability based on the amount of data collected. Figure 1 shows the distribution of vulnerability scores versus reliability, demonstrating that, of the species assessed as highly vulnerable, over 50% were regarded as having good/reliable data and only about 10% as having low reliability data.

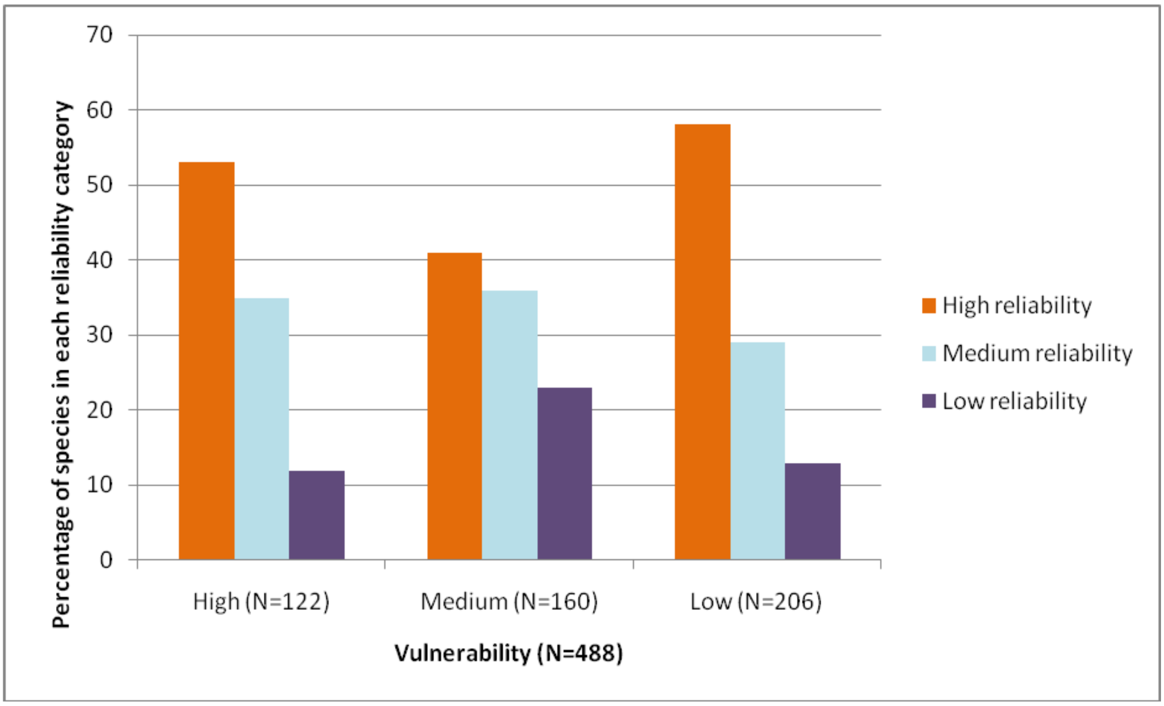

Figure 1. Levels of data reliability for species assessed as having high, medium and low vulnerability (N=488)

Figure 2 shows that the number of species categorised as being of high vulnerability are also those most often identified in IUCN Red List assessments, including draft assessments, as having decreasing populations. Figure 2 also shows that a large number of species that have unknown population trends, according to the IUCN Red List, have been classified as highly vulnerable in this assessment. Furthermore, it shows that a large number of the species selected have not yet been assessed by IUCN and, as such, their extinction risk is unknown; however, the vulnerability assessment indicates the majority of these species, based on biological characteristics, may not be particularly vulnerable. Figure 3 shows that more than 50% of the species classified as threatened (CR, EN or VU) by IUCN were categorised as highly vulnerable, while less than 10% of low-vulnerability species have been assessed by the IUCN Red List as threatened. A similar pattern is shown with those categorised as Near Threatened, whereby over 50% were categorised as highly vulnerable. Forty four percent of low-vulnerability species are assessed as not threatened and over 50% are considered Data Deficient (DD) or have not been assessed yet. However, 13% of those identified as having high vulnerability are DD or not assessed and therefore may be species of priority for future Red List assessments.

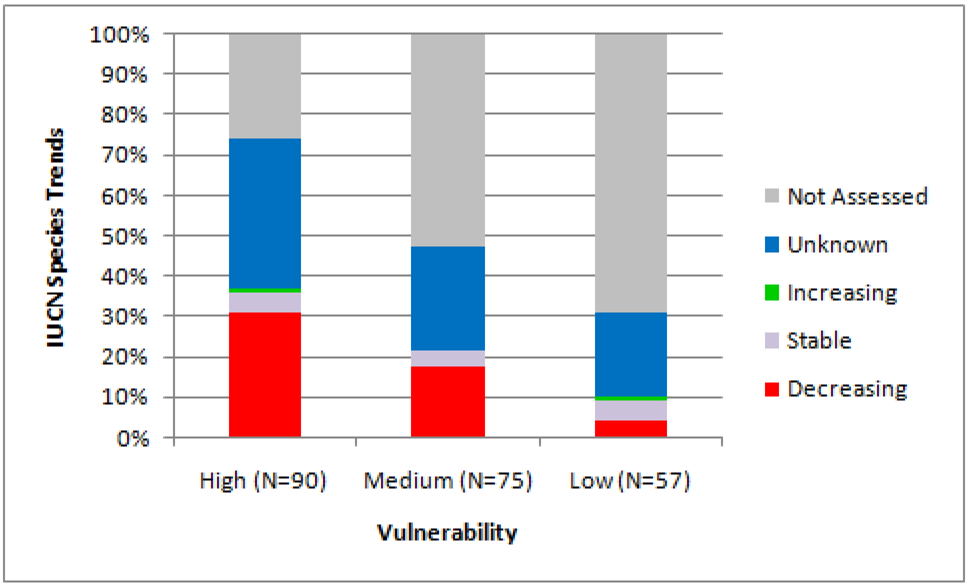

Figure 2. Population trends according to IUCN Red List Assessments (and draft assessments, N=8) against assessed vulnerability scores.

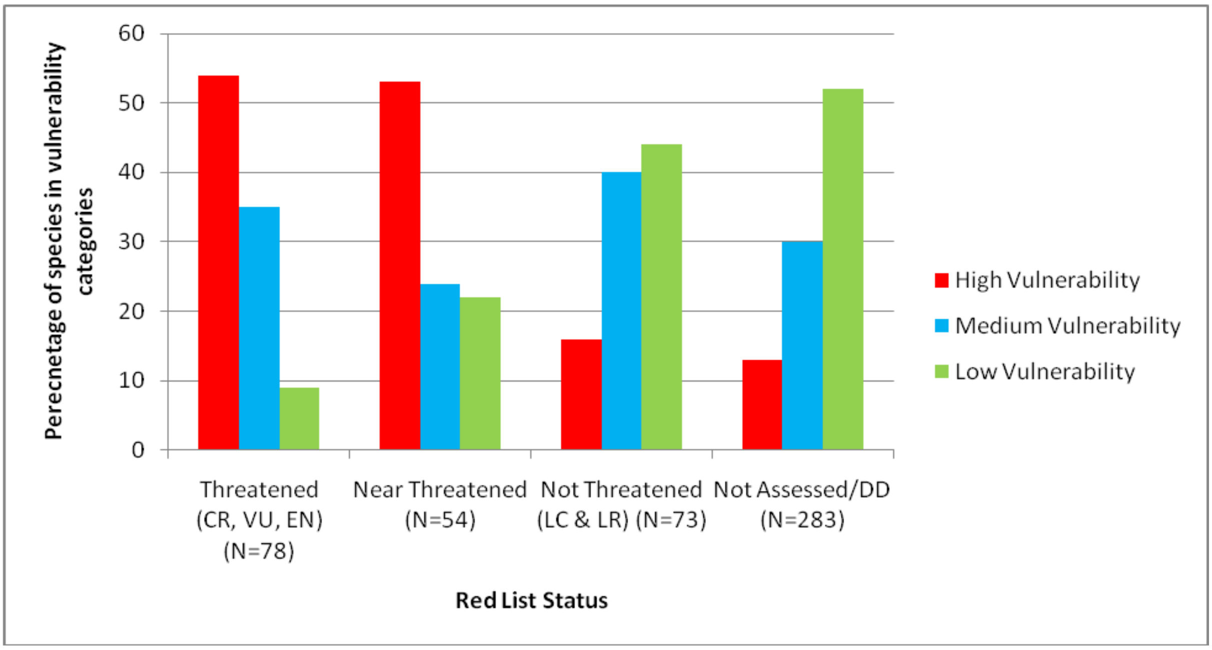

Figure 3. Percentage of species threatened according to the IUCN Red List charted against assessed vulnerability

A number of CITES-listed species and species previously, but unsuccessfully, proposed for listing were included in the analysis. Figure 4 shows that species proposed unsuccessfully for listing were more often classified as highly vulnerable than species which are currently listed or non-listed species, and only 7% were classified as having low vulnerability.

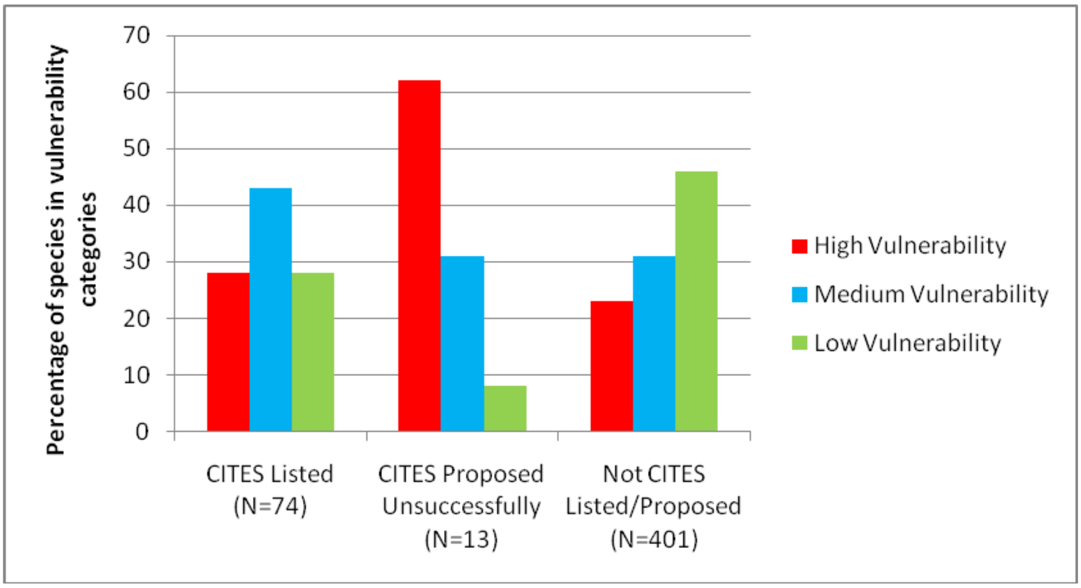

Figure 4. Percentage of species CITES-listed, unsuccessfully proposed, and not CITES-listed in each vulnerability category (N=488)

Of species listed in the CMS Appendices, 67% had a high vulnerability score.

4.5 Discussion

When compared with IUCN Red List Assessments, it appeared that vulnerability assessments were frequently (if not always) comparable, suggesting this method of assessment is effective, even when available life history information is only partial. That said, Red List Assessments take into account all threats and use a different set of criteria (http://www.iucnredlist.org/technical-documents/categories-and-criteria).

The relationship between CITES-listed species and species' vulnerability was examined and showed species listed in CITES as most often being of medium vulnerability and the majority of species proposed for listing as being highly vulnerable. It should be noted that CITES listing criteria (Res Conf. 9.24 (Rev CoP 15) http://www.cites.org/eng/res/all/09/E09-24R15.pdf) vary greatly from the criteria set in this project to assess species' vulnerability.

Although every effort was made to use reliable sources, due to time restrictions, the reliability of all the resources used could not be verified. Greater reliability of data may have been achieved if data from all available resources were gathered on each biological characteristic for each species and then an overall average calculated. This was not a possibility given the number of species investigated. Subsequent users of this methodology may concentrate on a smaller set of species, in which case, this may be feasible.

The validity of using the same biological characteristics for such a broad spectrum of species is potentially questionable. Given more time and resources, it may be valuable to investigate the validity of using a 'one size fits all' scoring system. Alternative scoring systems were considered for various taxonomic groups; for example, for corals, it might be necessary to look at strategies of reproduction in more detail: species employing multiple reproductive strategies may be presumed less vulnerable than those employing just one strategy. Other factors, such as dispersal distance and time to settlement, could also be considered. To investigate such factors was outside the project scope and contradicted the notion of the database, which is intended to be a useful and relatively simple assessment tool for all aquatic species. Furthermore, the aim of the database was to devise a simple methodology which could be applied to all aquatic fish and invertebrates. Further, CSIRO uses the same cut-off values and biological characteristics to assess aquatic fauna ranging from marine mammals to aquatic invertebrates and it has carefully tested this methodology and produced results to suggest that it is valid for assessing productivity. An additional consideration is that, where the final vulnerability scores were based on information on very few biological characteristics (i.e. had low reliability), the vulnerability assessment must be treated with extreme caution.

5 Value

5.1 Introduction

Ideally, a value assessment would consider the relative net income potential (i.e. value at sale less the cost of fishing, processing, transport and onward sale) from fisheries against other potential sources of income available to fishers. However, there is general paucity of value data along fisheries trade chains and collection of this type of data was not possible within the limited time period for the large number of species assessed in this project.

Another simpler approach for determining species value would be to analyse trade value data. However, as with determining trade levels, determining a single monetary value for a traded 'species' is fraught with difficulties and further compounded by the limitations of the reported data. An individual of a species may yield a number of different products, for example, an individual shark of a particular species may provide meat, skin, fins and oil and the value of each of these products varies widely. Furthermore, different life stages of the same species can have very different 'values'. For example, live juvenile eels *Anguilla* are traded on the international market for hundreds of dollars per kilogramme, whereas adult live eels fetch < USD10/kg.

Since the value of different parts and products of the same species can vary widely, attempts to apply the average value from such trade can be misleading. Determining the true value of a species would require details of the various commodities being traded, in addition to this being reported at species level: neither type of information is readily available for most species.

The availability of landing values to species level, on the other hand, is more readily available, with the University of British Columbia having developed a comprehensive database for global ex-vessel (landing) prices for a large number of commercially exploited species. The value assessment carried out under this project was therefore predominantly based on this resource, combined with NOAA landing data and trade data where appropriate.

5.2 Identifying unit price

The most comprehensive source of value data currently available is that compiled by the Sea Around Us Project and Fisheries Economics Research Unit of the University of British Colombia (UBC). Their database (hereafter referred to as the 'ex-vessel database') provides global real and nominal ex-vessel fish prices for all major marine species exploited for food consumption. They intend to make these data publically available in the future, but at present only limited summaries and general patterns derived from this database are available online, at http://www.seaaroundus.org/data/. On request, however, UBC extracted global average price data for the period 1950–2006 (comparable to 2005 USD rates), from which data from the most recent 10-year period (1997–2006) were analysed to determine average value (USD/kg) for as many of the 505 species selected, using the criteria outlined in section 3.4, as possible. The ex-vessel database included specific value data for over 60% of these 505 species. For those species for which species-specific prices were not available, either genus, family or, in some cases, even higher taxonomic group values from the ex-vessel database were selected.

The ex-vessel database focuses on marine species used for human food consumption purposes. Therefore, price information (to either the species or higher taxonomic levels) was not available for freshwater species nor for any marine species used for non-food purposes (aquarium trade, jewellery, cosmetics, etc.). For any species for which no price data could be found in the ex-vessel database, price information to species or higher taxonomic levels from the following sources was analysed:

- average US landings data for the most recent 10-year period available (1999-2008), provided by NOAA;
- average global FAO trade commodity value for the most recent 10-year period available (1998-2007); and/or
- average US LEMIS trade commodity value for 2001-2003 (the only years for which value data were available from LEMIS).

5.3 Scoring for value

Prices were classified into three categories, namely low, medium and high, with cut-off values for categories based on those suggested in NOAA's Vulnerability Evaluation Working Group Report (Patrick *et al* undated). The NOAA cut off values set at <USD1/lb (low), USD1–2.25/lb (medium) and >USD2.25/lb suggested by Patrick *et al* were modified according to the units used in the current project (USD/kg) (see Table 8).

Table 8. Scoring for value

Price range (USD/kg)	Value classification	Value score
0–2	Low	1
>2–4.5	Medium	2
>4.5	High	3

Levels of reliability of the price data were noted in terms of whether the available price data were specifically for that species (S) or to a higher level only (HL). It was not possible to incorporate these scores into the final value scoring system, however, and therefore caution must be exercised when using value derived from non-species-specific information.

5.4 Identifying high-value species

Although average price per species (either landing or trade value) was considered a good basis on which to compare values of different species, it was noted that two other major factors related to a species' value would need to be taken into account, due to the role they were likely to play in the 'desirability' and over-exploitation of certain species, namely 1) trade in commodities of considerably high value for certain species with overall low or medium unit price values and 2) high overall landing value based on high catch volumes per year (incorporated into NOAA value classifications as per Patrick *et al* undated).

Owing to frequent differences in value of various products and life stages derived from a single species (see section 5.1), unit price may not always be an appropriate measure of overall value. In order to identify those species whose specific products are known to be traded at very high values, and for which the overall average value (as per landing data) may be misleading in terms of determining desirability and incentives for over-exploitation, experts were consulted. Species such as sharks (for shark fins), sturgeons (for caviar) and eels (for glass eels) were consequently highlighted in the database as having 'high-value commodities'. In addition, some species were also considered as 'high-value' if they had a particularly high catch volume, i.e. FAO catch data average of over 500,000 t/yr. These two additional factors were taken into consideration when selecting highly vulnerable and high-value species for consequent violability analysis in section 6.

5.5 Results

Information on prices (USD/kg), price reliability, value scores, high-value commodities and resources used are provided in the "Value data" worksheet of the database. Overall value results are summarised in Table 9.

Table 9. Overall value score results for the 505 selected species

Value score	No. of species	Price available to species level (%)
High	93	34
Medium	83	66
Low	300	75
No information	29	n/a
High-value commodity	121	n/a

Nearly 20% of the 476 species for which price data were available were identified as being 'high-value'. However only 34% of the prices for these 93 species were derived from species-specific information (in particular due to all coral species being categorised as high-value as per NOAA data for the group "corals") resulting in a low reliability for this category. For those species with species-specific price data, three stood out as having very high average values of over USD10/kg, namely southern bluefin tuna *Thunnus maccoyii* (USD12.73/kg), Caribbean spiny lobster *Panulirus argus* (USD10.85/kg) and American hard-shelled clam *Mercenaria mercenaria* (USD10.52/kg).

Of the 121 species highlighted as including a 'high-value commodity', nearly 50% were identified as being 'low value' according to unit price data, confirming the need to incorporate this commodity factor in any assessment to establish the true value of species.

5.6 Discussion of value data limitations

UBC has compiled ex-vessel price data for the world's commercial species from a number of sources including the US National Marine Fisheries Services, Statistics Norway, Southeast Asia Fisheries Development Centre and FAO-Globefish, plus the web, published literature and local data. For those species for which data were still missing after exhaustive research, UBC developed an 'interpolation process' (see Sumaila *et al* 2007 for more details), which ensured that all catch records from the Sea Around Us project's global catch database, regardless of taxon, country, region and year, would have prices assigned to them. At the time of writing, this was therefore considered the most comprehensive resource available for global landing values.

It is, however limited to marine species for consumption purposes and therefore alternative resources were needed to determine prices for freshwater and marine species used for other purposes. In these cases, other data sources such as NOAA landings, FAO trade data and LEMIS trade data were analysed, but the use of these different datasets naturally resulted in additional issues concerning reliability and comparability of data (not only related to taxonomic levels).

NOAA records values of US landings only. Therefore, the prices are not globally averaged. However, when comparing NOAA values to UBC ex-vessel values, no general trend in differences between the two datasets were apparent and therefore no general compensation/adaptation of the data (for example via the lowering of all NOAA prices by a certain percentage to make them comparable to global ex-vessel prices) could be incorporated. However, the NOAA/ex-vessel comparison was vital to determine whether the NOAA-derived value categories should be adapted to make them applicable to global values.

FAO trade data (weight and value) are limited to the commodities as described by Customs codes, often only to the level of genus, family or a more general taxonomic group. According to FAO trade data, trade in only ~60 aquatic species is reported to the species level, severely limiting the potential use of this data source in determining species-specific value. Furthermore, unit prices derived from FAO trade data are reliant on accurate Customs reporting. Prices derived from FAO trade data would be expected to be higher than landings prices, as they refer to commodities that have already entered into the trade chain. However, as for the NOAA/ex-vessel comparison, no general trend in price differences between ex-vessel and FAO trade data could be identified. For this project, FAO trade data were used to infer the value of only one species, for which no information was provided in the other sources, namely the Nile perch *Lates niloticus*.

LEMIS trade data are more species-specific than FAO trade data, however are limited to US imports, exports and re-exports, again potentially leading to a skew in prices. Furthermore, value is not reported for all LEMIS entries (and was also only available for a three-year period, 2001–2003) and, where it is, it is generally associated with highly-modified and consequently highly-priced products, such as jewellery made from coral. On the other hand, these highly-priced commodities are usually traded in low volumes and the importance of these high-value products can often be under-estimated by overall landings weights and prices reported and by trade in general commodities. To compensate for this, information from LEMIS, FAO trade data and expert opinion was used to add an additional ‘high commodity’ criterion to the value assessment, as described in sections 5.2–5.4.

6 Violability

6.1 Selection of species

Ideally all species would be coded for vulnerability, value and violability in order to produce an overall risk score for every species included in the assessment process. However, due to time restrictions and the huge variety of taxa covered in this project it was necessary to use the scoring of vulnerability and value to focus on a new subset of species in the violability stage of the project.

The following process was used to select this new subset. Species which scored, on average, two or above for vulnerability and value combined were selected for the violability analysis. This meant the species either had medium value and/or medium vulnerability, or scored highly for one or the other. In addition, a representative subset of species with parts and derivatives of high commercial value, and species with very high total catches, based on expert opinion, were added to the final list.

This resulted in a list of **109 species only** for which violability was considered in the next stage of this study.

6.2 Assessing violability

Violability, as defined by FAO (2000), is the risk to species arising from the extent to which conventional management measures may be circumvented, i.e. the 'compliance risk'. For the purposes of this study, violability has been extended to include risks arising from there being no management in place consistent with achieving sustainable harvest. This extended definition was considered necessary since many fish species are effectively unmanaged or subject to poor management measures only. Thus, compliance would not be a meaningful indicator of violability, as the species may still be at risk due to management being inadequate to ensure that harvest does not exceed sustainable levels.

Consideration was given as to whether species value might be incorporated as an element of violability. The rationale for doing so is that there is greater incentive for non-compliance where the rewards are high, i.e. where the fish is of high value. However, since the methodology already includes value as one of the three core components of risk, it was felt that to include value in violability would amount to double counting.

Fisheries for many of the species in trade will occur in more than one location, will, or should, be subject to more than one management jurisdiction, will be conducted by a variety of types of fishing operations and will take species as both target and non-target catch. This complexity influences the type of management measures required for sustainable management and the feasibility and relevance of the application of MEAs.

Vulnerability and value can be assessed on a species basis, regardless of the distribution of the species, of whether one or more stocks exist, and of the nature of the fisheries taking that species. However, a meaningful assessment of violability as defined in this study must necessarily take into account the stocks of a species and the fisheries in which the species is taken, since the nature of management and enforcement can vary considerably across these. This increases the complexity and the level of information required for comprehensive evaluation of violability.

The assessment of species' violability in this study was therefore comprised of two elements:

1. assessment of the management arrangements in place for a species, which involved
   a. analysis of the *characteristics* of the species and the fishery/ies in which the species is taken, including location, management jurisdiction, the scale of the fishery and the nature of the catch (target/non-target); and
   b. consideration of the nature and appropriateness of the *management measures* in place, given the above characteristics, which involved consideration of whether a stock assessment had been conducted and of the nature of harvest-related and trade-related measures in place for the species, or stocks of that species; and

2. assessment of *compliance risk* based on the nature of the monitoring, control and surveillance (MCS) measures in place to enforce management.

Each of these components of violability is discussed below.

6.2.1 Characteristics of the species/fisheries

i Location

The fish species under consideration in this report may be:

- freshwater species found only in inland, freshwater waterways;
- diadromous species that use both marine and freshwater habitats during their life cycle (species can be anadromous, living primarily at sea but migrating up rivers to spawn, or catadromous**,** living primarily in lakes, ponds and rivers but migrating out to sea to spawn);
- marine species found only within the national waters of one or more States;
- marine species, separate stocks of which occur in national waters and on the high seas;
- marine species, stocks of which straddle the national waters of one or more States or straddle the national waters of one State and the high seas (referred to as straddling stocks);
- marine species that carry out migrations across EEZs and high seas (referred to as migratory species); or
- marine species found only in the high seas (discrete high seas fish stocks).

Fisheries for species identified in the database have, therefore, been categorised in the database as occurring in one or more of the following:

- freshwater bodies;
- national marine waters (EEZs); and
- high seas, i.e.in marine waters beyond the areas of national jurisdiction (which can be 200 nautical miles or less).

The location of fish stocks is significant since it determines the nature of the governance arrangements (bilateral, multilateral, etc.) required to ensure sustainable fishing of these resources. A brief review of some important concepts and how they have been applied in this study is therefore warranted.

There is no compiled list of straddling stocks. Article 63, clause 2 of UNCLOS refers to straddling stocks as "the same stock or stocks of associated species [that] occur both within the exclusive economic zone and in an area beyond and adjacent to the zone", and this definition of the concept of straddling stock has been used in this study.

Definitions of 'migratory species' vary. UNCLOS identifies a list of 'highly migratory species' but does not define the term. Maguire *et al* (2006) have interpreted the term as species that are ‘in general, capable of migrating relatively long distances, and stocks of these species are likely to occur both within EEZs and on the high seas’ (Maguire *et al* 2006). However, CMS, which applies to a broader range of species than the marine species identified in UNCLOS, defines ‘migratory species’ as:

> “the entire population of any geographically separate part of the population of any species or lower taxon of wild animals, a significant proportion of whose members cyclically and predictably cross one or more national jurisdictional boundaries”.

The CMS definition of migratory species therefore appears to encapsulate both ‘highly migratory’ and ‘straddling stocks’ as defined in UNCLOS.

The IUCN Red List uses another definition of ‘migratory species’ as being a substantial proportion of the global or regional population makes regular or seasonal cyclical movements beyond the breeding range, with predictable timing and destinations (C. Hilton-Taylor, *in litt* March 2011).

The sources used in identifying ‘migratory species’ for this project are discussed in Section 3.3.

ii Management jurisdiction

Depending on the nature of the species (freshwater, highly migratory, straddling, etc.), legal authority, i.e. management jurisdiction, for fisheries for these species can reside with:

- solely one or more national governments operating independently to manage stocks of these species wholly contained in their waters;
- two national governments operating under an agreed bilateral management arrangement for straddling stocks of these species; or
- a number of national governments operating under an agreed multilateral fisheries management arrangement, usually taking the form of an RFMO.

As noted above, if species are migratory or some stocks are straddling stocks, this has implications for assessment of the appropriateness of the management arrangements in place. A highly migratory species that is commercially exploited should be subject to management under an RFMO. Fisheries exploiting a straddling stock should be managed under arrangements developed by the relevant EEZs and those flag States exploiting any high seas component of the stock.

While the legal authority may exist to manage fisheries, this authority is not always exercised. For example, a national government may not manage some or any of the fisheries operating in its waters. Similarly, some fisheries that operate in the high seas take species that are outside the management mandate of existing RFMOs. In each case, these fisheries can be regarded as unmanaged.

Some species may be subject to CITES and/or CMS listings. Responsibility for implementation of obligations under CITES, or decisions to co-operate voluntarily under CMS, rest solely with the individual parties to these MEAs regardless of whether bilateral or multilateral arrangements for these species are in place.

iii Scale

Fisheries are generally identified as artisanal, small-scale or industrial. Different stocks of the same species may be fished by fisheries of different scales and products from any one of these categories can enter international trade. There is no internationally agreed consensus on how these categories should be defined and the distinction between the groups is often blurred. Common features used to distinguish these categories are:

- the nature of the operator (i.e. individual or company);
- the level of capital investment;
- the size of the fishing vessel (if any vessel);
- the length of fishing trips (hours, days, weeks, etc.);
- the location of fishing (inshore, offshore, on the high seas);
- the use of catch (for subsistence consumption, local consumption, international trade); and
- the availability of freezing/processing facilities on board the vessels.

FAO does not distinguish between small-scale and artisanal fisheries because the “subtle differences between them are hard to pin down” (FAO 2011a). Both artisanal and small-scale fisheries may be commercial (i.e. not subsistence) fisheries and products from both may enter international trade. Both artisanal and small scale fisheries may catch highly migratory species. Thus, for the purposes of this report it was considered that there was little value in discriminating between them, and they have been grouped as artisanal/small scale fisheries.

While ‘industrial’ fisheries are not homogenous, the distinction between artisanal/small scale fisheries and industrial fisheries is more clear. Unlike artisanal/small scale fisheries, industrial fisheries are all commercial fisheries with the majority of product destined for international markets. The term ‘industrial fisheries’ is often used to refer to fisheries that catch fish in bulk to process on board into fish oil or fish meal. However, large trawlers and longliners that fish on the high seas for example, for Patagonian toothfish *Dissostichus eleginoides* or tunas, are also generally regarded as industrial fisheries. The size of vessels and freezing and/or processing capacity required to operate on the high seas for extended periods characterises these fisheries. For the purposes of this study ‘industrial fisheries’ have therefore been characterized as those that predominantly comprise vessels having freezing and/or processing capacity.

Some species in international trade and/or some migratory species are also taken in recreational fisheries. However, fish taken in recreational fisheries are more likely to be consumed by the catcher or locally, or to be tagged and released. In some countries, it is illegal for recreational fishers to sell their catch. As a result it has not been considered necessary to include recreational fisheries in this study.

iv Nature of catch

Fishing operations can target a particular species or group of species. Target fishing is particularly common in industrial fisheries. However fishing gear is not completely selective and in most fishing operations non-target catch will also be taken. However, the extent of non-target catch is variable and will depend on the type of fishing gear used, how selective it is for the target species and whether fishing is carried out on spawning or feeding aggregations of species. Species that form such aggregations are easier to target and fishing for them generally results in relatively lower rates of non-target catch. These species are, however, often susceptible to over-fishing given the relative ease with which they can be caught.

Throughout its range, within a year in the same fishing area, or across different fishery types, a single species can be target and/or non-target catch, and as non-target catch can be either retained or discarded. Regardless, unmanaged catch of a species can place that species at risk. For management (including risk assessment) purposes, it is important to know whether a species is predominantly target or non-target catch.

It was not considered necessary to draw a distinction between retained and discarded non-target catch in this study—the presence of the species in trade indicates that at least some portion of the catch is retained. Species have therefore been identified as either target and/or non-target species.

6.2.2 Management of aquatic organisms

In many cases, fisheries management is based on management of stocks of species rather than on species in their totality. While some species form a single stock throughout their range (e.g. southern bluefin tuna), other species comprise geographically separate stocks (e.g. bigeye tuna *Thunnus obesus,* which forms different stocks in the western Pacific Ocean, the eastern Pacific Ocean, the Atlantic Ocean and the Indian Ocean). Each 'fish stock' represents a group of individuals that occupy a well-defined spatial range independent of other stocks of the same species. For fisheries management purposes, such groups, or even a subset of a group, can be regarded as a management unit (FAO 2011b). The specification of such management units, known collectively as stock structure, is critical to determining the impact of fishing. This stock-based approach means that a species may be subject to a variety of management responses throughout its range, as management authorities manage stocks of those species in their national waters or on the high seas.

A wide range of management techniques are used to manage fish stocks. Broadly, these measures relate to controlling the quantity of catch, the nature of the catch, the amount of fishing effort, where and/or when fishing can occur and/or controls on trade of the species. Effective application of such measures requires a framework of data collection, scientific assessment of fishing operations and fish stocks, and monitoring, control and surveillance of regulations.

An FAO workshop (FAO 2012) considering the application and effectiveness of international regulatory measures for the conservation and sustainable use of shark species adopted a useful classification of management measures as follows:

- scientific data collection and stock assessment models;
- harvest-related measures;
- trade-related measures; and
- compliance measures.

An overview of the type of management measures falling within each of these four groups is provided below. A more comprehensive discussion of fisheries management measures can be found in King (2007).

i Scientific data collection and stock assessment

Data required for fisheries management depend on factors including:

- the scale of the fishery;
- the sophistication of the scientific and economic models used for stock assessment and fishery modelling;
- the nature of the management arrangements;

- the level of risk that is acceptable to the management regime; and
- the level of investment in reducing uncertainty that the management regime is prepared to make.

While improvements in the nature and extent of the data available may enable more informed management, it is increasingly recognised that the absence of data should not preclude the adoption of management measures to reduce the risk of unsustainable fishing impacts on fish stocks. This concept is central to the precautionary approach, the application of which is encouraged by key international instruments including the United Nations Fish Stocks Agreement[10] (UNFSA) and FAO's Code of Conduct for Responsible Fisheries (FAO 1995).

Nevertheless, the basic set of desirable data for fisheries management might include:

- basic biological data on the species including data on age, growth, migration, segregation, diet and reproduction;
- temporal and spatial distribution of fish stocks (stock structure);
- catch information on target species including numbers, weight, size and life status (dead or alive) when captured;
- catch rates of target species;
- catch information on non-target species; and
- trade information on retained species, including numbers, weight, size, sex and source.

Assessment of stock status can be based on monitoring of fishery indicators, such as catch-per-unit-effort (CPUE), or on the outputs of stock assessment models of varying degrees of sophistication (equilibrium or non-equilibrium surplus production models, delay difference models, age structured models, etc.). Depending on the location and nature of the stock, a stock assessment may be done by a single management authority or in conjunction with adjoining coastal States or an RFMO.

By and large, stock assessment is generally applied only to target species for which the commercial returns are regarded as warranting the investment in data collection and stock assessment models. A spectrum of methodologies for data collection and stock assessment applies across species and across stocks of the same species. At one end of this spectrum is a complete lack of assessment for any stock of the species. Along the spectrum, there are various levels of rigour applied assessment of individual stocks of the species. At the other end of the spectrum, there is rigorous stock assessment for a single stock, or for some or all of the exploited stocks of the species.

This complexity causes difficulties for definitive assessment of whether stock assessments are in place for a 'species' as is required for the database. Where more than one stock exists, more often than not stock assessment will be in place for only some stocks of a species.

ii Harvest-related measures

Harvest-related measures, as their name suggests, are those management measures that affect how the fishery harvests fish. In an effective management system, a combination of measures is developed to achieve specified management objectives. The management regime is informed by stock assessments and/or ecological risk

[10] The Agreement for the Implementation of the Provisions of the United Nations Convention on the Law of the Sea of 10 December 1982, relating to the Conservation and Management of Straddling Fish Stocks and Highly Migratory Fish Stocks.

assessments and the integrity of the regime is maintained through the conduct of a comprehensive monitoring, control and surveillance (MCS) programme.

Typical harvest-related measures are described in Table 10. Each of these measures has advantages and disadvantages and its own MCS requirements, but examination of these is beyond the scope of this study.

Table 10. Typical harvest-related measures used in fisheries management

Measure	Description and Aim/s
Limited entry	Aim: to limit access to the fishery to a specific group or number of operators as the first step in controlling fishing effort Implementation: typically through the issue of some form of fishing right such as a fishing permit or license
Fishing time restrictions	Aim: to limit fishing effort by restricting the number of days that fishers can operate Implementation: through adoption of fishing seasons (e.g. fishery open from May to September and closed from October to April) Aim: to increase selectivity of fishing operations so as to minimize the take of certain segments of the target stock, or of non-target species Implementation: through implementation of time restrictions (e.g. fishing only between dusk and dawn)
Fishing gear restrictions	Aim: to limit fishing effort by controlling the quantity of gear that can be deployed or the type of gear that can be used Implementation: through controls on the number of hooks, length of net or prohibition on use drift nets, use of light sticks, etc. Aim: to improve the selectivity of the gear so as to avoid catching particular sizes/life stages of target species or non-target species Implementation: through restrictions on net mesh size, mouth opening of traps, etc.
Permanent area closures	Aim: To protect a certain segment of the target species population (e.g. spawning grounds, nursery area) Implementation: through spatial closure
Sanctuaries	Aim: to minimise fishing mortality of one or more species or to protect certain habitat/ecosystem types Implementation: through prohibitions on all fishing in an area (e.g. through declaration of a marine protected area in which no fishing is allowed) or the prohibition on the retention of certain species (e.g. via the declaration of so-called shark sanctuaries)
Total allowable catch (TAC)	Aim: to limit fishing mortality on a species or a group of species Implementation: through the establishment of a species/species group catch limit for the fishery as a whole in relation to a defined period (e.g. a fishing season or year)
Individual transferable quota (ITQ)	Aim: To provide individual fishers or community groups with security of access to a specific portion of the TAC which can be caught. The right to catch the quantity of fish associated with the ITQ can be traded with others either seasonally (leased) or permanently (sold) Implementation: Allocation of the TAC across eligible fishers, usually expressed as as a percentage of the TAC
Fishing trip limits	Aim: To control mortality of target or non-target species Implementation: a per vessel limit on the quantity of fish that can be landed at

Measure	Description and Aim/s
	the end of a fishing trip
Prohibited Catch	Aim: To minimise fishing mortality of a certain species Implementation: Through prohibitions on the landing of a specified species and often the requirement to ensure that any incidental catch of the species is immediately returned to the sea without further harm in order to maximise the chances of post-capture survival
Fish size limits	Aim 1: To prevent growth over-fishing by ensuring that the market value of fish is maximized and/or to prevent recruitment over-fishing by allowing each fish to spawn at least once prior to capture Implementation: through imposing minimum legal size limits on retained fish Aim 2: to maximise the contribution of individuals to the stock Implementation: through maximum size limits that preclude the retention of mature individuals beyond a certain size (usually associated with age)
Gender-based restrictions	Aim: to protect spawning females in order to miminise the impact of fishing on recruitment to the stock Implementation: through prohibition on retention of females or females bearing eggs
Product form restrictions	Aim: to reduce fishing mortality on a species Implementation: through requirements that a species can be landed only in a certain form, on the assumption, or knowledge, that this will provide a disincentive to retention of the species, e.g. requirements for sharks to be landed with fins attached or that shark fins can only be landed with the associated trunks
Move-on provisions	Aim: To minimise fishing mortality of a certain species, usually a non-target species Implementation: though requiring fishers to move a specified distance from a fishing ground when catch rates of a species reach a specified level
By-catch reduction devices	Aim: To reduce fishing impacts on non-target species Implementation: through the use of specified by-catch mitigation devices such as turtle excluder devices, seal excluder devices, seabird scaring lines, circle hooks, etc.
Buy-back schemes	Aim: To reduce fishing effort by removing the number of vessels and/or fishing entitlements in a fishery Implementation: through a scheme, usually government-sponsored, designed to acquire and dispose of excess fishing capacity from the fishery

For many of the non-target species examined in this project, the management measures in place may be generic rather than species-specific. A good example is provided by shark species that are commonly taken as non-target species in many types of fisheries. A typical management measure for sharks, employed at both national and RFMO level, is that of ‘finning bans’, which essentially means that it is illegal, at sea, to remove the fins of a shark and discard the carcass. Such measures apply to all shark species taken in the relevant fishery, regardless of the vulnerability of the species taken. However, it is possible and recognised elsewhere (e.g. FAO 2009) that such measures have mitigated, to some extent, the impact of fishing on sharks. As a result, the analysis of management in this project recognises the potential impact of generic management measures, even though it may not be possible to make a definitive assessment of the impact of these measures on the individual species under examination.

iii Trade-related measures

Where used, trade-related measures are generally in conjunction with harvest-related measures. The most common forms of trade-related measures are summarised in Table 11.

Table 11. Common trade-related measures used for fisheries products

Measure	Operation
Documentation schemes • catch documentation schemes (CDS) • trade documentation schemes (TDS)	Schemes that require documentation to accompany fish product in order to authenticate its legitimacy. CDS cover all catch regardless of whether it is landed and used in the catching country or traded internationally, whereas TDS cover only catch that enters international trade.
Vessel lists • white lists • black lists	Lists used by RFMOs. White lists identify vessels authorised to fish in the area of the RFMO and black lists identify vessels considered or determined to have been fishing in breach of RFMO measures. Black lists are used as a basis for imposing restrictions on the access of the listed vessels to ports through the introduction of port State measures.
Trade bans	Trade bans imposed by the parties to an RFMO on particular States/entities considered to have failed to co-operate in the implementation of an RFMO's conservation and management measures.
Eco-labelling/certification schemes	Schemes that confirm to consumers that traded fish products are taken from sustainably managed fisheries

Source: Lack (2007).

Documentation schemes, vessel lists and trade bans have been used extensively by RFMOs since the mid 1990s. The adoption of these measures was prompted largely by the deteriorating status of key commercial fish stocks, uncertainty as to the actual levels of fishing mortality on these stocks; and the undermining of conservation and management measures by IUU fishing. Such measures have been applied to species including Atlantic bluefin tuna *Thunnus thunnus*, southern bluefin tuna, bigyeye tuna, swordfish *Xiphias gladius,* Patagonian toothfish and Antarctic toothfish *Dissostichus mawsoni*. Over time, these measures have come to be used as a package of mandatory conservation measures adopted by RFMOs and supported by vessel monitoring systems (VMS), observer programs and controls on transhipment.

Lack (2007) identified the following objectives of the trade-related measures adopted by RFMOs:

1. to reduce the opportunities and incentives for IUU fishing by
   - precluding or impeding access to markets for IUU product, thereby reducing profitability and, ultimately, the economic incentive for IUU fishing,
   - tracing the movements of fish products in order to identify those involved in catching, transhipping and marketing illegally caught product as a basis for imposing sanctions on those participants, and

- monitoring changes in the pattern of trade to identify flag, port and market States that can contribute to the effective implementation of conservation and management measures; and/or

2. to improve information on fishing mortality by verifying landings of members within and outside the area of competence of the RFMO and by detecting IUU-caught product.

Eco-labelling is a voluntary measure used at the fishery or sub-fishery level to realise the potential market advantage attached to sustainably certified seafood. The number of seafood products bearing eco-labels, such as those of the Marine Stewardship Council, Friend of the Sea, Naturland, Krav, AIDCP, Mel-Japan[11] and Southern Rocklobster, has risen markedly over the last decade.

Experience to date has shown that:

- significant improvements in estimates of fishing mortality can only be achieved through the use of schemes that apply at the point of harvest, i.e., CDS rather than TDS;
- TDS have failed to prevent IUU fishing or provide significant improvements in catch data since they monitor only subsets of the catch and of the supply chain;
- CDS are not capable of providing meaningful estimates of total fishing mortality and need to be supplemented by other mechanisms to provide a reliable and timely record of catches, discards and other incidental mortality from commercial operations and, where relevant, mortality from recreational fishing; and
- documentation schemes must apply to all sectors of the fleet (regardless of size or gear), all forms of product (live, fresh, frozen, traded, for domestic consumption) and all stages of the catching, landing, transport, processing, trading and marketing chain.

In addition to the above measures, CITES provides a potential mechanism for regulating trade in species. The operation of CITES is discussed in more detail in Section 7.

[11] Further details of these eco-labels can be found at: http://www.msc.org/; http://www.friendofthesea.org/;http://www.naturland.de/naturland_fish.html; http://www.krav.se/sv/System/Spraklankar/In-English/; http://www.iattc.org/DolphinSafeENG.htm ; http://www.melj.jp/eng/index.cfm and http://www.southernrocklobster.com/ respectively.

6.2.3 Compliance measures

Failure to ensure compliance with harvest and trade-related measures compromises the integrity of these measures and effectively wastes the investment in management, data collection and stock assessment. A strong MCS regime is an essential component of an effective fisheries management regime. The nature of the MCS regime required will vary according to the type of fishery and the range of harvest and trade-related measures in place.

FAO (2011c) defines the elements of MCS as follows:

- Monitoring the collection, measurement and analysis of fishing activity including, but not limited to: catch, species composition, fishing effort, by-catch, discards, area of operations, etc. This information constitutes primary data that fisheries managers use to arrive at management decisions. If this information is unavailable, inaccurate or incomplete, managers will be handicapped in developing and implementing appropriate management measures.
- Control involves the specification of the terms and conditions under which resources can be harvested. These specifications are normally contained in national fisheries legislation and other arrangements that might be nationally, sub-regionally, or regionally agreed. The legislation provides the basis for which fisheries management arrangements, via MCS, are implemented.
- Surveillance involves the regulation and supervision of fishing activity to ensure that national legislation and terms, conditions of access and management measures are observed. This activity is critical to ensure that resources are not over exploited, poaching is minimized and management arrangements are implemented.

The nature of data required to underpin effective management has been discussed above. The mechanisms for collection of data and the distinction between fishery-dependent data and fishery-independent data are critical to determining the credibility of management arrangements. Fishery-dependent data, such as those collected by fishers in logbooks, are influenced by decisions taken at sea to maximise commercial returns to fishing. They are also influenced by fishers' capacity and preparedness to complete logbooks accurately. Fisheries-dependent data, collected by well-trained, on-board observers, overcome these issues. Fisheries-independent data, usually collected through scientifically designed, fisheries-independent surveys, which are conducted independently of commercial fishing operations also overcome these issues.

The nature of possible harvest and trade-related measures has also been discussed above. In an MCS context, it is critical that such measures have legislative backing, including the specification of penalties for non-compliance with the measures, to provide a deterrent to, and penalise where necessary, non-compliance.

Commonly used surveillance tools, that seek to ensure compliance with harvest- and trade-related measures include:

- vessel monitoring systems (VMS) using satellite monitoring of fleet location and activity and providing for real-time transmission of data;
- at-sea and in-port inspections of vessels and processing facilities to ensure compliance with management measures and controls;
- oversight of at-sea transhipment of product;

- observer programmes where observers have a dual role of collecting data and monitoring compliance with management measures; and
- electronic or paper-based systems for monitoring compliance with catch levels.

6.3 Scoring for violability

Given the determinants of violability, compiling a comprehensive set of information to underpin violability scoring for even the subset of 109 selected species is extremely difficult. In making decisions on the rigour of management and on compliance with management to determine a violability score, the following criteria were considered:

- scale of the fishery;
- target or non-target catch;
- fishery location;
- management jurisdiction;
- stock assessment;
- harvest-related measures;
- trade-related measures (including look-alike issues); and
- MCS measures.

Assessment of these criteria, particularly where a single species has multiple stocks, is complex and the availability of information on these management measures varies enormously both between and within species and different fisheries. As a result, judgments had to be made on violability on the basis of limited and incomplete information. The scoring system developed (see Table 12) reflects the difficulties in gathering this background information for species and hence the development of a scoring system based around management and non-compliance information, which considers the degree to which adequate management has been adopted and is adequately enforced. This scoring system should be regarded as the first step only in understanding and scoring for violability in a meaningful way. In addition, it was considered useful to provide a reliability score (see Table 13) which reflected the amount of information available to score for violability, the extent to which available sources of information reported on all stocks of a species, and the credibility of the source of the information. The reliability score has not been incorporated into the violability score, but is provided for information and interpretation purposes.

Table 12. Scoring system for violability

	Violability score	Description
Very High Violability	5	No management for any exploited stock throughout the range of the species **OR** Very high risk of non-compliance[1]
	4	Management varies from **less rigorous management**[2] to **no management** for exploited stocks throughout the range of the species; **OR** High risk of non-compliance[2]
	3	**Less rigorous management** which extends to all exploited stocks throughout the range of the species **OR** Management varies from **rigorous management**[4] for some stocks to **no management** for some stocks throughout the range of the species; **AND** Low to medium risk of non-compliance [5,6]
	2	**Rigorous management** for some exploited stocks and **less rigorous management** for others **AND** Low risk of non-compliance
Very Low Violability	1	**Rigorous management** for all exploited stocks throughout the range of species **AND** Low risk of non-compliance

1. Very high risk of non-compliance—No MCS programme or evidence of systematic non-compliance demonstrated by a comprehensive MCS programme
2. High risk of non-compliance—some MCS measures in place and some evidence of non-compliance.
3. Less rigorous management—Management strategy in place based on fishery indicators (e.g. CPUE) rather than a stock assessment and therefore higher risk of unsustainable catch levels OR Management strategy in place that does not reflect the best available scientific advice
4. Rigorous management—Appropriate reference points, stock rebuilding strategy in place for deplete stocks, management strategy in place consistent with reference points and informed by a stock assessment OR A precautionary management strategy adopted in the absence of information
5. Low risk of non-compliance—No evidence of, or evidence of intermittent and low levels of, non-compliance as demonstrated by a comprehensive MCS programme
6. Medium risk of non-compliance—No evidence of non-compliance but MCS programme is limited in scope; OR Evidence of ongoing and low to medium non-compliance as demonstrated by a comprehensive MCS programme

Table 13. Violability reliability scores

Score	Description
3	Very reliable: violability score is based on sources that describe the management and its enforcement.
2	Less reliable: violability score is based on a range of sources that either do not fully cover all stocks of the species or are less authoritative on the subject
1	Not very reliable: violability score is based on very limited information.

6.4 Results

Of the 109 species selected for the violability analysis, 82 species were successfully allocated an overall violability score, 67 of which were classified as having inadequate management/less rigorous management of some or all exploited stocks and medium to high risk of non compliance, i.e. medium to very high violability (see Table 14). As previously mentioned, each violability score was given a reliability score. For the species identified as having medium-very high violability, 97% of these scores were classified as having either high or medium reliability. Where species have low reliability scores, the data must be interpreted with this in mind.

Table 14: Number of species within each violability category

Violability score	Violability level	Number of species
1	Very low violability/good management and compliance	6
2	Low violability	9
3	Medium violability	31
4	High violability	25
5	Very high violability/poor management and compliance	11

6.5 Discussion

During this project an early attempt was made to give individual scores to each of the violability variables described above in an attempt to derive a final violability score for each species. However, the number of species to be assessed and the lack of information or difficulty in accessing information on management of species throughout their range meant that this was not possible. To do so in a meaningful and consistent way across species, so as to allow for the development of relative violability rankings of species, would require considerably more time and resources. Further it is questionable, even with additional resources, whether such scores could be derived for all species due to lack of available information.

There is also a risk of bias inherent in any comparative scoring of violability between species as those fisheries with the greatest level of reporting, management and enforcement are fisheries for which it is easier to find information on issues or risks associated with a species and for which better management is in place. In turn, if there is little information on management measures for species, this suggests such measures may be lacking or poorly implemented and therefore, inherently, violability is high.

Further work is needed to refine what information is the most applicable in scoring for violability, if it is to be used as a useful index of risk. The overall conclusion of this analysis is that violability is very difficult to reduce to a system capable of simple scores, due to a lack of relevant information and, in particular, it is very difficult to make meaningful comparisons of violability across species and different stocks given the variable information base, the inconsistency in the information available, and the level of subjectivity involved in scoring. One of the methods adopted to try and reduce subjectivity was to use a broader scale scoring system (i.e. 1–5). Unlike for value and vulnerability, for which overall scores of one to three were applied, it was necessary to include scores from one to five in order to account for the various levels of management and non-compliance and to allow more of the information to be incorporated into an overall score.

Further consideration of assessment of the management components of violability might usefully be informed by systems developed by Monterey Bay Aquarium's Seafood Watch® programme and by the Blue Ocean Institute[12]. The Monterey Bay programme evaluates the ecological sustainability of wild-caught and farmed seafood commonly found in the US marketplace. Seafood Watch has developed a set of five sustainability criteria, to evaluate capture fisheries for the purpose of developing sustainable seafood recommendations for consumers and businesses. These criteria[13] are:

1. Inherent vulnerability to fishing pressure
2. Status of wild stocks
3. Nature and extent of discarded by-catch
4. Effect of fishing practices on habitats and ecosystems
5. Effectiveness of the management regime

Similarly, the Blue Ocean Institute evaluates fisheries (at the species level) to advise consumer choices in their *Guide to Ocean Friendly Seafood.* Their ranking methodology also evaluates species' life history, abundance in the wild, habitat concerns, and catch method or farming system. Life-history (vulnerability) is ranked on the basis of; intrinsic rate of increase, **or** age at maturity **or** growth rate **or** maximum age in years.

[12] For further details see http://www.blueocean.org/home

[13] For further details see Appendix 1 of http://www.montereybayaquarium.org/cr/cr_seafoodwatch/content/media/MBA_SeafoodWatch_DungenessCrabReport.pdf

7 CITES and CMS

7.1 CITES

CITES is a legally-binding global treaty. The main purpose of CITES is to provide a regulatory framework for international co-operation to prevent the over-exploitation of wild species through international trade by:

- providing a mechanism for the prevention of international trade in species threatened with extinction; and
- assisting in the effective regulation of international trade in species that might become threatened with extinction in the absence of such controls.

Under CITES, 'trade' includes import, export, re-export and introduction from the sea. The last-mentioned of these elements is of particular significance for this report. The term 'introduction from the sea' is defined under CITES as "…transportation into a State of specimens of any species which were taken in the marine environment not under the jurisdiction of any State".

CITES operates using three Appendices in which species can be listed. The three Appendices are:

- Appendix I, which includes species threatened with extinction and international trade in specimens of these species is permitted only in exceptional circumstances;
- Appendix II, which includes species not necessarily threatened with extinction, but in which international trade must be controlled in order to avoid use incompatible with their survival; and
- Appendix III, which includes species that are protected in at least one country and that country has asked the CITES Parties for assistance in controlling the trade.

A species may be listed in more than one of the CITES Appendices and this is commonly referred to as a split-listing. The term also applies where a population (or sub-species) of a species may be listed and another of the same species not listed. Split-listings are considered a valuable tool under CITES, given that the conservation status of a species may vary considerably across its range (Willock, 2004). This is potentially relevant in fisheries where measures might vary depending on the stock or geographic area concerned. However, they are also discouraged due to implementation difficulties and can be of concern with migratory species which may cross borders and as such be subject to different provisions.

The provisions controlling trade in a listed species vary according to the Appendix in which it is included (see Table 15). Listings of species in Appendix I and II are determined by CITES Parties at each of their meetings of the Conference of the Parties (CoPs). Listing criteria have been adopted for the Appendices, against which proposals to list taxa should be assessed (CITES Res. Conf. 9.24 Rev. CoP15). For Appendix III-listed species, each Party is entitled to make unilateral amendments.

Table 15. Summary of conditions for trade under each CITES Appendix

Appendix	*Permit conditions*	*Export Permit Required?*	*Re-Export Certificate Required?*	*Import permit required*
I	Not for primarily commercial purposes; trade not detrimental to the survival of the species or on the extent of territory occupied; trade is legal; avoids cruel or injurious shipping of live specimens	Yes—granted only if import permit already in hand	Yes—granted only if in accordance with CITES and there is a valid import permit	Yes
II	Trade not detrimental to the conservation of the species or extent of territory occupied; trade is legal; avoids cruel or injurious shipping of live specimens	Yes	Yes—granted only if import was in accordance with CITES	No—requires prior presentation of the export permit, certificate of origin, re-export permit or re-export certificate (whichever applicable)
III **Party has listed the species**	Trade is legal; trade avoids cruel or injurious shipping of live specimens	Yes	Yes—granted on the basis that the specimens were processed in/ re-exported from that State	No
III **Party has not listed the species**	Specimen originated from that Party	No—certificate of origin		

Source: Based on Willock (2004).

Parties to CITES are legally obliged to comply with the requirements of the Convention for listed species. However a Party can take out a 'reservation' on species listings, in which case they are treated as a non-Party to the Convention with respect to that species until their reservation is withdrawn.

In addition, despite their obligations under CITES, the rigour with which Parties comply with these varies considerably and, as a consequence, implementation of listings can be inconsistent and less than comprehensive. In many cases, this reflects the lack of capacity of the Parties to ensure compliance with the listing requirements rather than deliberate non-compliance. In contrast, Parties may take domestic measures stricter than those of CITES. For example, the European Union and Australia have implemented stricter measures for Appendix II-listed species, such that permits must be issued for imports.

The Convention does have provisions through which it can penalize non-compliance with its requirements. For example, trade in a particular species with a particular Party can be suspended or, in certain circumstances, trade with a non-compliant Party may be suspended for all listed species. However, these steps are usually only taken as a last resort, for example if recommendations made by CITES committees have not been implemented.

When Parties issue permits for the export of Appendix-II species, they need to make a legal finding (i.e. the Management Authority of the State of export is satisfied that the specimen was not obtained in contravention of the laws of that State) and a non-detriment finding (NDF) to permit the trade. An NDF is a determination that the harvest and trade of the specimens in question are not detrimental to the species. Marine species under CITES also have special conditions that apply where a species is caught in an area not under the jurisdiction of a State (i.e. in the high seas). In this case, 'Introduction from the sea' applies and requires the State of introduction to make an NDF, but no legal finding is required unless the product is subsequently exported. An agreed understanding and application of 'Introduction from the sea' remains unresolved in CITES and consideration of this issue continues under the CITES Working Group on Introduction from the Sea. Key issues under consideration by the Group include:

- a definition for 'transportation into a State';
- clarification of the term 'State of introduction'; and
- the process for issuing certificates of introduction from the sea.

Resolution of these issues is becoming increasingly urgent as the number of proposals for listing of marine species, especially those that are taken on the high seas, increases. Continued uncertainty around interpretation and application of 'introduction from the sea' acts as an impediment to listing of such species.

There are currently 175 Parties to CITES (nearly 90% of the world's countries). This far exceeds the number of members of any regional fisheries arrangement, whether relating to marine or freshwater stocks. In addition, membership of RFMOs generally includes only coastal and/or fishing States. The wide membership of CITES provides far greater coverage by also including port States and market States. This reach is one of the strengths of CITES. The benefits that CITES may offer fish species are discussed below:

- Where there is no management or less rigorous management in place for a species, a CITES listing would require legal findings and NDFs to be conducted to permit trade. In order to conduct legal findings and NDFs it can be assumed that a certain level of management and compliance will need to be in existence. This may necessitate CITES Parties adopting more rigorous management measures to implement the listing.

- Listing of species in CITES could result in improved data collection on trade in that species, where trade is from or to a CITES Party. Further, consideration of species of concern by the CITES Parties can in itself, without a listing, focus attention on the collection of better information on the status and management of these species, to ascertain whether trade poses a risk to that species. For example, CITES adopted a resolution on shark conservation and management despite the fact that at the time there were no shark species listed in CITES. This resulted in more information being collected for these species. Similarly, improved data collection has resulted from CITES consideration of seahorses and sea cucumbers.

- Where there are no existing controls over trade, or trade controls by an RFMO do not extend to all players in the trade chain, a CITES listing would be useful as it would extend to all CITES Parties. Therefore, CITES could provide more comprehensive coverage of countries within the trade chain for a species, to help enforce trade-related measures.

- A strong deterrent to non-compliance with management measures are punitive measures when non-compliance is detected. Where no regional agreement is in place, or there is an RFMO with no punitive measures in place, CITES has a very clear process for the restriction of trade and has powers to restrict trade completely from Parties that do not implement CITES adequately.

- While CITES applies only to international trade, non-detriment findings for internationally traded species should take into account the impact of all catch, including for domestic consumption, on the species. As a result, CITES has potentially greater impact than trade documentation schemes that do not apply to domestically-consumed products.

Further, CITES ensures that products taken on the high seas and landed in the flag State requires an NDF (through 'introduction from the sea' provisions). In contrast TDS do not apply to such product. CITES, therefore has the potential to provide greater protection on a species basis than do TDS.

It is important to note that CITES listings of marine species can complement rather than replace traditional fisheries management measures. Where management is proving inadequate to prevent species becoming endangered or where non-compliance with the management measures is problematic, CITES could potentially increase the effectiveness of management and, as mentioned before, CITES can help extend RFMO measures to market and port States.

CITES Parties have listed nearly 100 fish and other marine species, including 2,000 coral species, in the CITES Appendices. To date, no marine species taken in a large-scale, industrial commercial fishery has yet been listed in CITES, despite a number of proposals to list such species (for example, Atlantic bluefin tuna, Patagonian toothfish, spiny dogfish *Squalus acanthias* and porbeagle *Lamna nasus*).

The appropriateness of CITES for listing of exploited and managed marine species remains a matter of contention. Some CITES Parties argue that listing of marine species in CITES Appendices conflicts with the role of FAO and RFMOs. Cochrane (undated) identifies some of the specific issues that have been raised as concerns:

- the appropriateness of the listing criteria and guidelines to reflect the specific characteristics of aquatic resources;
- differences of opinion about the intention of Appendix II;
- implications of the CITES 'look-alike' clause, which allows the listing of species that are difficult to distinguish from a species listed/to be listed in Appendix I or II for conservation reasons;
    - so called 'look-alike' issues are key when considering the likely effectiveness and feasibility of CITES listings for marine species; in fact many fish species are listed in CITES due to look-alike concerns. However, the issue of species identification is generally not insurmountable. The development and use of species identification guides for enforcing species-based fisheries and/or trade management measures can often overcome or minimise the problem.
- the potential for unnecessary negative impacts on fishing industry and communities; and
- the need for greater input from national fisheries agencies in elaboration of proposals and from FAO in evaluation of proposals for listing;
- the need for de-listing procedures to be objective, responsive and flexible to cope with the resource variability.

FAO has actively engaged with CITES on issues associated with listing of marine species for over a decade. Key aspects of that relationship include the following:

- CITES has adopted revised listing criteria based in part on recommendations from FAO;
- FAO has convened Expert Advisory Panels in 2004, 2007 and 2009 to evaluate proposals and to make recommendations to CITES for listing of commercially-exploited aquatic species;
- FAO and CITES have jointly convened workshops on sea cucumbers, sturgeon and queen conch and sharks;
- FAO actively engaged in an international NDF workshop; and
- in 2006, CITES and FAO signed a Memorandum of Understanding (MoU) to guide the relationship between the two bodies.

It has to be recognised that there are also potential costs associated with CITES measures, including reduced revenue owing to trade restrictions and a need for expenditure on practical implementation and regulation.

Listing in the CITES Appendices may result in costs to the industry or to communities dependent on harvest and income from trade if trade levels are restricted. Although not an integral part of the CITES listing criteria, socio-economic impacts are often raised when discussing proposals and it is likely to be a factor that is considered when Parties make decisions to support proposals or not. However, listings in CITES Appendix II or III would not necessarily lead to reduced trade volumes. Even in cases where trade volumes were decreased, market responses may raise prices for the remaining legal and sustainable supply.

Implementing the procedural mechanisms for regulation of trade in species listed in the CITES Appendices results in implementing costs to the industry and for Parties that permit the export, re-export and import of those species. These costs relate largely to species listed in Appendix II or III, although illegal trade in all three Appendices may require the application of enforcement-related resources for these species. Costs incurred may include:

i) research upon which to base non-detriment findings;

ii) processing of permit applications, compilation and submission of annual reports; and

iii) inspection of imports and exports and detection and prosecution of illegal trade (Willock, 2004).

The extent to which additional costs will be incurred by a Party as a result of CITES listing will depend on;

- the extent to which they are engaged in trade of the species;
- the existing administrative and enforcement infrastructure; and
- whether a species to be listed falls under the responsibility of an RFMO and to what extent there are already trade-related measures such as a CDS in place (which may in fact reduce costs).

In many cases, administrative costs will be addressed through licence fees.

7.2 CMS

The objective of CMS (or the Bonn Convention) is to conserve terrestrial, marine and avian migratory species throughout their range. CMS acts as an intergovernmental treaty under which legally binding global or regional Agreements or less formal MoUs can be developed. Agreements and MoUs can be adapted to the conservation needs of species and the requirements of regions. CMS currently has 115 Parties (nearly 60% of all countries). In addition, countries that are not CMS Parties can participate in CMS Agreements and MoUs and a further 33 countries participate in the work of the CMS in this way. The CMS does not specify any non-compliance procedures (Rose *et al* 2005) or mechanisms to penalize non-compliance.

The benefits of CMS have been analysed previously (see for example CMS 2007). The key benefits appear to be:

- to focus attention on a discrete set of migratory species within any given geographic area which is particularly relevant where RFMOs are generally geographically based and cover numerous species or in the case where there is no regional co-operation;
- to identify and motivate action by the range States most relevant to these species; and
- to facilitate joint action, information exchange and integration, and best practice development.

CMS lists species in one or both of two Appendices:

- Appendix I, which lists migratory species that are endangered (i.e. are in danger of extinction throughout all or a significant portion of its range); and
- Appendix II, which lists migratory species that need or would significantly benefit from international co-operation (CMS 2011).

A species is listed in Appendix I provided that reliable evidence, including the best scientific information available, indicates that the species is endangered. Parties that are range States (i.e. any State that exercises jurisdiction over any part of the range of that migratory species, or a State, flag vessels of which are engaged outside national jurisdictional limits in taking that migratory species) of a migratory species listed in Appendix I are expected to prohibit the taking of animals belonging to such species (except for specified reasons) and endeavour to:

- conserve and, where feasible and appropriate, restore those habitats of the species which are of importance in removing the species from danger of extinction;
- prevent, remove, compensate for or minimize, as appropriate, the adverse effects of activities or obstacles that seriously impede or prevent the migration of the species; and
- to the extent feasible and appropriate, prevent, reduce or control factors that are endangering or are likely to further endanger the species, including strictly controlling the introduction of, or controlling or eliminating, already introduced exotic species.

Species listed in Appendix II are those migratory species that are considered to have an unfavourable conservation status and which require international agreements for their conservation and management, as well as those which have a conservation status which would significantly benefit from the international co-operation that could be achieved by an international agreement. Parties that are range States of migratory species listed in Appendix II shall endeavour to conclude Agreements where these should benefit the species and should give priority to those species in an unfavourable conservation status. Further, Parties are encouraged to conclude Agreements for any population or any geographically separate part of the population of any species or lower taxon of wild animals, members of which periodically cross one or more national jurisdiction boundary. This can encourage regional co-operation, joint management and stock assessments.

If the Parties consider it warranted, it is possible for a species to be listed in both Appendix I and Appendix II. For example, the Great white shark is listed in both Appendices.

In respect of the fish species considered in this study, CMS lists 15 species of sturgeon (one species in both Appendix I and II and 14 species in Appendix II), the Chinese paddlefish *Psephurus gladius* in Appendix II, the giant catfish *Pangasianodon gigas* in Appendix I and six species of shark (two in both Appendix I and Appendix II and four in Appendix II), and one population of a shark species in Appendix II. To date, no Agreements have been developed for species of 'fish', as defined in this study, but an MoU has been agreed for the listed shark species[14].

[14] Available from http://www.cms.int/species/sharks/MoU/Migratory_Shark_MoU_Eng.pdf

As with CITES measures, it has to be recognised that there are also potential costs associated with CMS measures, including reduced revenue owing to trade restrictions and a need for expenditure on practical implementation and regulation.

The nature and extent of costs incurred as a result of a CMS listing will also depend on whether an Agreement or a legally non-binding MoU is also negotiated. The nature, and therefore the costs, of implementing MoUs and Agreements will vary. States are bound by the provisions of an Agreement; Parties incur new substantive and financial obligations and must create institutions (e.g. a Secretariat) that oversee the Agreement's implementation. MOUs theoretically do not impose new, additional substantive or financial obligations to their signatories. They are typically agreements between the governmental institutions in the range States responsible for the species' conservation, although these conservation measures may have associated costs. Listing in Appendix I of CMS prohibits harvest, both for international and national trade and local use, potentially impacting on any fishing industry or communities dependent on fishing of that species for income or for direct use.

8 Potential for application of MEAs

8.1 Potential for application of MEAs

For the 109 species assessed for violability, allocation to four groups was made on the following bases:

- Group 1: Species scoring highly on vulnerability (two or more) and value (two or more) and violability (three or more)
- Group 2: Species scoring highly on vulnerability (two or more) that were selected as having high-value commodities and a high score for violability (three or more)
- Group 3: Species for which scores could not be obtained for each of the value, vulnerability and violability categories, but which scored highly in one or more of these, and are therefore potentially at high risk
- Group 4: Additional species which scored highest for violability

When considering vulnerability, value and violability, 34 species were identified as being overall at high risk (see Table 16: Groups 1 and 2). An additional 12 species (Group 3) were also identified as potentially at high risk. Group 4 includes other species that emerged with a violability score of 5 but which were not included in groups 1-3.

Table 16. Species in trade at highest risk

Group	Scientific Name	Common name	IUCN Red List status	MEA	Migratory
1	*Corallium secundum*	Angel skin coral		CITES III	
1	*Ctenella chagius*	Coral	EN	CITES II	
1	*Dissostichus eleginoides*	Patagonian toothfish			Y
1	*Hippocampus algiricus*	West African seahorse	DD	CITES II	
1	*Hippocampus reidi*	Longsnout/slender seahorse	DD	CITES II	
1	*Hippocampus trimaculatus*	Longnose seahorse	VU	CITES II	
1	*Hippoglossus hippoglossus*	Atlantic halibut	EN		Y
1	*Huso huso*	Beluga	CR	CITES II, CMS II	Y
1	*Isurus paucus*	Longfin mako	VU	CMS II	Y
1	*Makaira nigricans*	Blue marlin			Y
1	*Millepora tenera*	Stinging coral	LC	CITES II	
1	*Montastraea annularis*	Boulder star coral	EN	CITES II	
1	*Montastraea faveolata*	coral	EN	CITES II	
1	*Octopus maya*	Mexican four-eyed octopus			
1	*Plerogyra simplex*	Bubble/grape coral	NT	CITES II	
1	*Pocillopora eydouxi*	Antler coral	NT	CITES II	
1	*Rastrineobola argentea*	Silver cyprinid	LC		
1	*Salvelinus alpinus*	Arctic charr	LC		Y
1	*Thunnus maccoyii*	Southern bluefin tuna	CR		Y
2	*Alopias vulpinus*	Thresher	VU		Y
2	*Anoxypristis cuspidata*	Knifetooth/pointed sawfish	CR	CITES I	
2	*Carcharhinus brachyurus*	Copper shark	NT		Y

2	*Carcharhinus obscurus*	Dusky shark	VU		Y
2	*Carcharodon carcharias*	Great white shark	VU	CITES II, CMS I&II	Y
2	*Centrophorus granulosus*	Gulper shark	VU		Y
2	*Centrophorus squamosus*	Leafscale gulper shark	VU		Y
2	*Cetorhinus maximus*	Basking shark	VU	CITES II, CMS I	Y
2	*Galeocerdo cuvier*	Tiger shark	NT		Y
2	*Hexanchus griseus*	Bluntnose sixgill shark	NT		Y
2	*Lamna nasus*	Porbeagle	VU	CMS II	Y
2	*Mobula mobular*	Devil fish/ray	EN		
2	*Pristis microdon*	Largetooth/Freshwater sawfish	CR	CITES II	Y
2	*Pristis zijsron*	Narrowsnout sawfish	CR	CITES I	?
2	*Sphyrna lewini*	Scalloped hammerhead	EN		Y
3	*Antipathes densa*	Black coral		CITES II	
3	*Arapaima gigas*	Arapaima	DD	CITES II	
3	*Channa striata*	Striped snakehead	LC		Y
3	*Corallium elatius*	Momo, boke magai, misu coral		CITES III	
3	*Cynoglossus microlepsis*	Smallscale tonguesole			Y
3	*Gymnarchus niloticus*	Aba	LC		Y
3	*Mormyrus kannume*	Bottlenose	LC		
3	*Octopus ocellatus*	octopus			
3	*Pangasius sanitwongsei*	Pangasid catfish	CR		Y
3	*Protopterus dolloi*	Slender lungfishes	LC		
3	*Scleropages formosus*	Asian bonytongue	EN	CITES I	
3	*Zungaro zungaro*	Gilded catfish			Y
4	*Dentex dentex*	Common dentex			
4	*Epinephelus aeneus*	White grouper	NT		Y
4	*Haliotis midae*	Abalone			
4	*Isostichopus fuscus*	Brown sea cucumber		CITES III	
4	*Katsuwonus pelamis*	Skipjack tuna			Y
4	*Labeo mesops*	Tanna labeo	EN		
4	*Somniosus microcephalus*	Greenland shark	NT		
4	*Thunnus thynnus*	Atlantic bluefin tuna	DD		Y

According to this framework, those species in Groups 1 and 2 which have the highest scores for value and vulnerability, as well as a high violability score, have the greatest likelihood of over-exploitation.

In the case of corals, the use of primarily generic data for harvest level (as a proxy for international trade), vulnerability and value, has resulted in some coral species being identified incorrectly in the highest risk category (Table 16). Further species specific information would be required to assess these more accurately.

Group 3 species would benefit from more research to determine overall risk, particularly those for which it has not been possible to score for violability. However, of particular note in group 3 are arapaima *Arapaima gigas*, aba *Gymnarchus niloticus* and pangasid catfish

Pangasius sanitwongsei, which have violability scores (4 or 5) on the basis of very reliable information. Of these, arapaima is already listed in CITES Appendix II. Aba and pangasid catfish are both migratory. Aba is currently considered 'Least Concern' by IUCN whereas pangasid catfish is considered CR.

Group 4 species scored highest for violability, mostly on the basis of reliable information (see Table 17). This indicates that management may not be in place, may not be rigorous and/or there is a high risk of non-compliance with management. Other than the Greenland shark *Somniosus microcephalus*, these species did not score highly for vulnerability—although some had a high value (such as common dentex *Dentex dentex* and white grouper *Epinephelus aeneus*), whether in terms of unit price or high-value commodity. Of particular note are the following:

- Greenland shark is in the highest risk category for vulnerability.
- Tanna labeo *Labeo mesops*, white grouper and common dentex all have high value scores, although further investigation may be warranted for the tanna labeo, for which value information was only available at a higher taxon level.
- Abalone *Haliotis midae* was, until recently, listed by South Africa in Appendix III of CITES but has now been removed.
- Ecuador has placed brown sea cucumber *Isostichopus fuscus* in Appendix III of CITES.
- Atlantic bluefin tuna rated a medium value score based on UBC value data yet it is considered to have a very high value and intuitively should have emerged as a high value species in the data base.UBC is still undergoing data verification and therefore this anomaly will be flagged with them.

Table 17. Reliability scores for the violability scores of the species in Groups 1–4.

	Violability score/Number of species		
Reliability	**5 (Very High)**	**4 (High)**	**3 (Medium)**
1 (Low)	1	1	1
2 (Medium)	1	2	10
3 (High)	9	17	6

Where species scored highly for violability this indicates that each of these species requires improved management and/or improved compliance with management in order to mitigate the risks associated with their inherent vulnerability and their demand in trade. A key question for this study is whether international co-operation through CITES and CMS has a role to play in improving management, or whether regional mechanisms, such as RFMOs, can be relied upon to deliver the necessary management for these species. This question is addressed below.

8.2 Potential benefits of CITES and CMS to highest risk species

In order to determine the role that CITES and/or CMS might play in improving management of the highest risk species identified in this study, the species in Table 16 can be split into migratory and non-migratory species and into species that are currently listed by one or both of CITES and CMS. This provides a basis for consideration of the most effective measures and the potential role of regional or international co-operation.

The benefits that CITES and CMS can offer in generic terms have been discussed in Section 7. An assessment of their potential benefits for the high-risk species identified from this study follows.

As noted in Section 7, many fish species have been proposed, unsuccessfully, for listing in CITES. In the assessment below, species which have been unsuccessfully proposed for CITES listing are identified. CITES listing proposals should be assessed against the CITES listing criteria, but Parties may also take into account other factors when deciding to support or reject a proposal, such as the benefits listing would provide to the conservation and management of the taxa, administrative costs associated with implementation, socio-economic effects, etc. However, 'benefits' are not specifically incorporated into the CITES listing criteria and a species may not be perceived as meeting these, but a listing in the Appendices may still potentially provide benefits to the management of the species. For example, the FAO Expert Panel established to comment on CITES proposals for fish species (FAO 2010b) did not consider that Coralliidae spp. met the listing criteria but concluded that, since international trade was a "driver of their harvesting, if such a listing resulted in a tightening of their management it could lead to an improvement in their status". As previously stated, this study did not assess any of these species against the CITES or CMS listing criteria.

8.2.1 Non-migratory species

There are 26 species non-migratory species identified in Table 16, for which the application of CMS is not relevant. Table 18 lists all non-migratory species from Groups 1-4 that are not listed in Appendix I or II of CITES. Species already included in Appendix I or II of CITES have not been further considered as discussions of this could stray into the realm of assessing the effectiveness of these listings, which is not the aim of this project. Species in Appendix III are included in the following discussions as listing the species in Appendix I or II may provide benefits beyond the App III listing.

Table 18. Non-migratory high-risk species not listed in CITES Appendix I or II

Group	Scientific name	Common name
1	*Corallium secundum*	Angel skin coral
1	*Octopus maya*	Mexican four-eyed octopus
1	*Rastrineobola argentea*	Silver cyprinid
2	*Mobula mobular*	Devil fish/ray
3	*Corallium elatius*	Momo, boke magai, misu coral
3	*Mormyrus kannume*	Bottlenose
3	*Octopus ocellatus*	Octopus
3	*Protopterus dolloi*	Slender lungfish
4	*Dentex dentex*	Common dentex
4	*Haliotis midae*	Abalone

4	*Isostichopus fuscus*	Brown sea cucumber
4	*Labeo mesops*	Tanna labeo
4	*Somniosus microcephalus*	Greenland shark

Little information was readily available on the fisheries and management for the bottlenose *Mormyrus kannume*, octopus *Octopus ocellatus* or slender lungfish *Protopterus dolloi*, hence no violability scoring was possible in this study. Further research would be necessary to determine current management and potential benefits from MEAs.

The remaining species in Table 18 are taken in artisanal or small scale fisheries (although the silver cyprinid *Rastrineobola argentea* catch is relatively high, averaging 45,000 t/yr) and all are target species. Most are caught in national marine waters or freshwater systems, with the two coral species harvested in national waters and the high seas. The silver cyprinid is managed under joint arrangements by several African countries and common dentex is managed by the General Fisheries Commission for the Mediterranean. All other species come under national management jurisdiction but it remains unclear whether they are effectively managed.

The two *Corallium* species have previously been proposed for listing in CITES although have not been listed. As noted earlier, The FAO Expert Panel, while not supporting the proposal indicated that there were potential benefits from a CITES listing. The devil fish/ray *Mobula mobular*, belongs to the Family Mobulidae which has previously been identified by CITES Animals Committee as a species 'of concern' (CITES Animals Committee 2009). As mentioned earlier, abalone is no longer listed in CITES Appendix III whereas Ecuador's population of brown sea cucumber is in CITES Appendix III.

All of the above species have high vulnerability and value and/or high violability scores and, as a result, management of these species and/or compliance with management requires strengthening. Regional co-operation through RFMOs is generally not relevant for these species, which are mainly harvested in national waters, including freshwater systems. International co-operation through CITES may be beneficial for these species. Further research is required to ascertain the specific benefits that a CITES listing might provide.

8.2.2 Migratory species

Migratory species can *potentially* benefit from improved management through RFMOs, CITES and CMS. There are 28 migratory or possibly migratory species identified in Table 16. Of those, beluga *Huso huso*, great white shark *Carcharodon carcharias* and basking shark *Cetorhinus maximus* are already listed by both CITES and CMS therefore these are not considered further here.

Of the remaining 26 species, two (longfin mako *Isurus paucus* and porbeagle) are listed by CMS and two (largetooth/freshwater sawfish *Pristis microdon* and narrowsnout sawfish *P. zijsron*) are listed in CITES. The applicability of additional MEA coverage for these four species is discussed below. This is followed by consideration of the potential benefits that CITES and/or CMS may provide to the 19 species which are not currently covered by an MEA.

i. Species already listed by CMS

This study indicates that there is very little international trade in longfin mako, suggesting that a CITES listing may be of little potential benefit. Given the lack of species disaggregation in shark trade data, trade in the species may warrant closer examination. Although there is limited reported catch of longfin mako, its life-history characteristics make it particularly vulnerable (score 2.71). Reported catch may also be low due to misidentification (confusion with shortfin mako *Isurus oxyrinchus*) and lack of species-specific reporting of retained fins

(Readon *et al* 2006). Longfin mako are taken predominantly as non-target catch in tropical tuna fisheries. Despite being listed in CMS Appendix II and coming under the management jurisdiction of a number of RFMOs, management is limited to generic shark finning bans and more rigorous species-specific management is required, including consideration of trade-related measures. Further information would be necessary to determine whether a CITES listing would be beneficial (See section 8.2.3).

Porbeagle has been identified by the CITES Animals Committee's Shark Working Group as of concern. Proposals to list this species in CITES Appendix II have been unsuccessful. Porbeagle is taken as both target and non-target catch and meat and fins of this species enter international trade. The CMS listing of this species is very recent and benefits from this are not yet evident. There is management, including stock assessment, harvest-related measures and some compliance measures, for some stocks only. No trade-related measures are in place. From the high violability score and its inherent vulnerability it would appear that this species warrants further management and would potentially benefit from listing in the CITES Appendices.

ii. Species already listed by CITES

Both largetooth/freshwater sawfish and narrowsnout sawfish are highly vulnerable and are considered to be Critically Endangered by IUCN. Although largetooth/freshwater sawfish is listed in CITES Appendix II, this is for the exclusive purpose of allowing international trade in live animals to appropriate and acceptable aquaria for primarily conservation purposes by Australia only. Hence, NDFs are only being conducted in Australia, although harvest measures are in place for some stocks. Compagno *et al* (2006a) identify by-catch as a significant threat. Largetooth/freshwater sawfish could potentially benefit from CMS intervention, as a major threat for the species is domestic catch as a non-target species of national fisheries. As a result, CMS may provide a mechanism for greater population and catch assessment by range States.

Narrowsnout sawfish is listed in CITES Appendix I and therefore international commercial trade is not permitted. Although harvest measures are in place for some stocks, it is extremely vulnerable to capture by target and by-catch fishing throughout its range (Compagno *et al* 2006b). Little is known about the ecology of *Pristis zijsron* and, although not specified as migratory in resources originally consulted (e.g. CSIRO, GROMS, CMS etc.), there is literature which suggests it may be amphidromous, moving between freshwater and estuaries of coastal catchments (NSW DPI 2006). If it were to be confirmed as a migratory species, Narrowsnout sawfish could potentially benefit from CMS intervention as a major threat for the species is domestic catch as a non-target species of national fisheries. As a result, CMS may provide a mechanism for greater population and catch assessment by Range States.

iii. Species not covered by any MEA

An assessment of the potential benefits of CITES and CMS to the remaining 19 high-risk species is provided in Table 19.

Table 19. Potential benefit of CITES and CMS to remaining high-risk species

Group	***Scientific name***	**Common name**	**Comments on management and application of MEA measures**
1	*Dissostichus eleginoides*	Patagonian toothfish	Patagonian toothfish is covered by an RFMO, the Commission for the Conservation of Antarctic Marine Living Resources (CCAMLR) which has an MoU with the CITES Secretariat. There is a CDS in place under CCAMLR which also deals with look-alike issues for Antarctic toothfish. The high violability score for Patagonian toothfish in this study largely reflects non-compliance issues and the failure adequately to control IUU fishing. The species has previously been proposed for listing in CITES. A listing of the species in CITES would give broader coverage throughout the trade chain of the species which is not provided by the membership of CCAMLR. This has the potential to address the ongoing problem of IUU fishing for this species. Willock (2002) has reviewed the implementation and potential benefits of listing this species in the CITES appendices, concluding that CITES could usefully complement measures through CCAMLR.
1	*Hippoglossus hippoglossus*	Atlantic halibut	IUCN classified this species as Endangered in 1996; this assessment is now out of date. The species is caught in national waters and the high seas in industrial as well as artisanal/small scale fisheries. There is no regional management of this species (see section 8.2.3). In order to assess whether CITES or CMS would benefit this species, further investigation would be required to assess the questions in section 8.2.3.
1	*Makaira nigricans*	Blue marlin	Blue marlin is widely traded and caught in areas covered by most tuna RFMOs. There is some management by RFMOs which could be greatly improved to benefit the species. There may be benefit in CITES listing, but greater understanding would be needed of the trade chain to understand whether additional States would be included compared with the limited RFMO coverage. There may be benefit in a listing on CMS to support a greater understanding of species catches and population structure within EEZs and on the high seas.
1	*Salvelinus alpinus*	Arctic charr	Listed by IUCN as Least Concern. It is a widespread species with no major threats identified (Freyhof & Kottelat 2008). The high vulnerability score was based on only two life history characteristics, further it is recognised that stocks vary in “mode of life, migration, growth, reproduction, food” (Freyhof & Kottelat, 2008), as such it is possible this is a false-positive result for this species.

			Mainly caught in artisanal/small scale fisheries as targeted catch in national waters. Some stock assessment, harvest-related measures and compliance measures are in place for some stocks. There is no regional management. In order to assess whether CITES or CMS would benefit this species, further investigation would be required to assess the questions in section 8.2.3 and more accurate biological data is required.
1	*Thunnus maccoyii*	Southern bluefin tuna	Southern bluefin tuna is managed under a single-species RFMO. There are stock assessment, harvest, compliance and a trade-related measure (through a CDS) in place for this species. The high violability score for southern bluefin tuna was based on the failure to implement a management procedure for this species. This is being addressed and should be in place in the near future. One member of the RFMO was found to have seriously exceeded its national allocation for some 20 years, but has had only very limited punitive measures brought against it. Southern bluefin tuna may benefit from a CITES listing as there are currently no agreed punitive measures in place in the RFMO for non-compliance with management measures for the species. A CITES listing could also potentially improve management of the species as it would require all catching States, including non-members of the RFMO, to conduct NDFs. There may be benefit in a CMS listing to enhance co-operation throughout the range of the species given not all catching or Range States are parties to the RFMO.
2	*Alopias vulpinus*	Thresher*	Included in the CITES Animals Committee’s Shark Working Group’s list of species of concern. This species occurs in trade with limited management in place and trade levels may be in excess of what is sustainable.
2	*Carcharhinus brachyurus*	Copper shark*	Included in the CITES Animals Committee’s Shark Working Group’s list of species of concern.
2	*Carcharhinus obscures*	Dusky shark*	Included in the CITES Animals Committee’s Shark Working Group’s list of species of concern.
2	*Centrophorus granulosus*	Gulper shark*	Included in the CITES Animals Committee’s Shark Working Group’s list of species of concern.
2	*Centrophorus squamosus*	Leafscale gulper shark*	Included in the CITES Animals Committee’s Shark Working Group’s list of species of concern.
2	*Galeocerdo cuvier*	Tiger shark	The CITES Animals Committee’s Shark Working Group considered this species and agreed that this species was not a species of concern. Harvest measures and compliance measures for some stocks only.
2	*Hexanchus griseus*	Bluntnose sixgill shark	Bluntnose sixgill shark appears to have very little international trade and therefore a CITES listing may be of little potential benefit. However, given the lack of species disaggregation in shark trade data, trade in this species may warrant closer examination.

2	*Sphyrna lewini*	Scalloped hammerhead*	Included in the CITES Animals Committee's Shark Working Group's list of species of concern. Unsuccessfully proposed for CITES listing in Appendix II at CoP15.
3	*Channa striata*	Striped snakehead	A freshwater fish, widespread in Asia and possibly introduced in other countries, although there is some confusion over species (Courtenay & Williams 2004). The species is reported as being cultivated in Pakistan and India and Sri Lanka. The species is considered to be Least Concern by IUCN and no threats have been identified. It would appear that the selection of this species on the basis of a medium vulnerability and high commodity value (with no violability score possible) has wrongly identified a species that is not in fact at risk. The high commodity value has skewed this.
3	*Cynoglossus microlepsis*	Smallscale tonguesole	A freshwater species from Asia. With a high (2) vulnerability and a high value, both of which had poor reliability. No information was available on the status of or threats to this species. Further research would be necessary to determine the current management of this species, its violability and the potential application of MEAs or regional management.
3	*Gymnarchus niloticus*	Aba	A freshwater species with a wide distribution in Africa, with no known major widespread threats and listed as Least Concern by IUCN (Azeroual et al 2009), however it could be regionally extinct within north Africa. This is a commercially important species in central Africa. The species is targeted in artisanal/small scale fisheries. Fisheries come under national jurisdiction, although it appears that there are no stock assessments, harvest, compliance or trade measures in place for this species and therefore it received a high score for violability on the basis of reliable information. It would be necessary to carry out further research to determine whether the species is being threatened by harvest and trade and whether regional or MEA measures are likely to benefit this species.
3	*Pangasius sanitwongsei*	Pangasid catfish	Pangasid catfish has been assessed by IUCN as Critically Endangered due to an estimated population decline of more than 99% over three generations (Jenkins et al 2007). Some stocks are managed, however, management appears to be inadequate and overfishing for food and to a lesser extent the aquarium trade, has depleted the natural population (Wang 1998). Understanding what proportion of harvest is in international trade and further research would be necessary to determine whether improved regional co-operation is necessary to improve management or whether CITES listing would provide any benefits to this species. A CMS listing may increase co-operation to tackle other threats to this species such as habitat modification affecting migratory patterns.
3	*Zungaro zungaro*	Gilded catfish	The gilded catfish was categorised as vulnerable in this study based on only one life history characteristic. No information was available on value or management. Further research would be

			necessary to determine what management was in place for this species and whether it required strengthening, and through what measures.
4	*Epinephelus aeneus*	White grouper	Targeted in artisanal/small scale fisheries in national waters. However these fisheries are unmanaged. This species had a very high-value score. The species is assessed as NT by IUCN, which notes that it has been heavily fished, particularly in its west African distribution area, and is most likely to have declined to close "to 30% throughout its range" (Thierry 2008). It would appear that management for this species is necessary. Further research would be necessary to determine whether regional management or MEAs would provide the necessary measures.
4	*Katsuwonus pelamis*	Skipjack tuna	Skipjack tuna is heavily commercially fished. The species was selected in the final 109 as a result of high catch volumes. It comes under the management jurisdiction of four tuna RFMOs. However, it is generally not managed hence its high violability score. According to this study, it has medium vulnerability (score: 1.57) and value scores. While it is caught in large volumes, it is regarded as quite a productive and abundant species.
4	*Thunnus thynnus*	Atlantic bluefin tuna	Atlantic bluefin tuna is considered the most expensive of all tuna species in the Japanese sashimi market and therefore it is surprising that it emerged with a medium value score. It is managed by the International Commission for the Conservation of Atlantic Tunas (ICCAT). Stocks are assessed and harvest, compliance and trade-related measures are in place. However, management has not been successful at maintaining the stock at sustainable levels and there is considerable non-compliance with management measures in place. This species was proposed for listing in CITES Appendix I at CoP15, which would have resulted in the halting of international trade for commercial purposes. However, the proposal was not adopted by the Parties. This study suggests listing in the CITES Appendices may potentially be of benefit, since it could help address the non-compliance issue through controls on trade.

The sharks in group 2 all scored very highly for vulnerability and although ex-vessel price was not high, they were scored as having particularly high commodity value. Thresher *Alopias vulpinus*, copper shark *Carcharhinus brachyurus*, dusky shark *Carcharhinus obscurus*, gulper shark *Centrophorus granulosus* and leafscale gulper shark *Centrophorus squamosus* are all caught in both target and non-target, industrial and artisanal/small scale fisheries. International trade is mainly in fins. Fins from different species are often lumped together in trade; identification is an issue. Some stocks are managed under RMFOs with stock assessments, harvest and compliance measures. None have trade measures in place.

Recorded catch is highest for the leafscale gulper shark, which is classified by IUCN as Vulnerable. Thresher, gulper shark and scalloped hammerhead *Sphyrna lewini* all have average catches of around 400 t/yr and are all considered threatened by IUCN.

Further species-specific research would be necessary to determine whether management could be improved through regional bodies and whether MEA listing would complement existing management. The questions in section 8.2.3 would need to be considered.

8.2.3 Further Information required for assessment of benefits from regional and MEA measures.

For assessment of the benefits of regional co-operation, information required includes:

- The number of range States
- The number of flag States (both range and distant water States) that fish for the species
- The number of fishing flag States that are already members of a relevant RMFO
- A comprehensive understanding of existing management arrangements for the species concerned and compliance with those arrangements.
- Knowledge of whether any relevant RFMO is a competent management authority (has rigorous management and compliance measures in place) for target and/or non-target species
- Knowledge of whether any relevant RFMO has the mandate to manage species that are taken mainly in national waters

For assessment of the benefits of a CITES listing, the following questions should be answered:

- Are there States in the trade chain that are not members of any relevant RFMO?
- Is catch taken in freshwater bodies, national marine water and/or on the high seas?
- Is there more than one stock of the species?
- Do any relevant RFMOs cover each of those stocks?

For assessment of the benefits of a CMS listing, the information required includes:

- The number of range States
- The number of flag States (both range and distant water States) that fish for the species
- The number of fishing flag States that are already members of the CMS
- A comprehensive understanding of existing management arrangements for the species concerned and compliance with those arrangements.

8.3 Common characteristics

The highest risk species identified in this study are a disparate group of species. The list includes a large proportion of sharks, a number of other finfish, freshwater and marine species and invertebrates. These species fall under a range of management jurisdictions including national, regional and international. For some of these species, the benefits of MEAs have already been identified through listing of these species in the Appendices of CITES and CMS. For others, lack of information effectively precluded any meaningful analysis of the potential benefits of CITES and CMS. For many others, the assessment of this study is that CITES and CMS offer potential benefits as supplementary management measures. As previously stated, no attempt has been made to assess the species against the listing criteria of these MEAs.

Of this group of species, the shark species emerge as a group that demonstrates a number of common characteristics. Most of these species are pelagic shark species which are predominantly taken as non-target catch in tuna fishing operations. Much of this catch appears in trade and, in particular, shark fins are of high value and are a highly traded commodity. The tuna fisheries in which these sharks are taken are under the management jurisdiction of five tuna RFMOs, none of which rigorously manage these non-target shark species.

Further, this study, suggests that, whether a species is target or non-target has little bearing on the quality of management and the subsequent need for management under MEAs. This study has identified the need for further research to confirm the potential benefits that CITES and CMS and regional co-operation, such as through RFMOs, may offer some high-risk species and the common set of information required to underpin that research.

8.4 Discussion

Most species identified in Table 16 require strengthened management. For most, further research would be necessary to determine whether an MEA listing would be beneficial, particularly for listing by CITES. Section 8.2.3 outlines some of the information that would be necessary to help determine this.

However, on the basis of available information, it would appear that listing of some species by an MEA could potentially benefit the management of those species. For instance, CITES listing could be of potential benefit to the two *Corallium* species, Patagonian toothfish, blue marlin *Makaira nigricans*, southern bluefin tuna, Atlantic bluefin tuna and all the shark species identified. The information available to this study for most of these species was highly reliable.

CMS offers the potential to encourage measures to address harvest for national consumption, by-catch, as well as other non-trade related threats for migratory species, and may have benefits for species such as largetooth/freshwater sawfish, narrowsnout sawfish, pangasid catfish, and aba. CMS could also potentially provide benefits to southern bluefin tuna, blue marlin and all the migratory shark species in the high-risk groups.

The framework developed in this study has seemingly resulted in misidentification of some species as high risk, it has resulted in some false positives. This is likely to have resulted from a number of different stages in the current project including:

- selection of species from the FAO catch list using a number of different criteria in order to represent: the range of species in trade; CITES and CMS listed species; migratory species; and threatened species;
- the necessary use of generic data for vulnerability and value where species-specific data were not available;
- lack of species specific data for some species;
- low reliability in the data available to score species; and
- the need to select a sub-set of species for violability assessment, which was primarily based on high vulnerability and value.

For similar reasons, it is likely that some high-risk species have not been detected by this methodology. While this study does not, therefore, provide a definitive list of high-risk species, it provides well-informed guidance as to which species should be further investigated to determine potential benefits from MEA listings.

9 Conclusions

This study has provided valuable insights into the range and extent of trade in fish species and of fisheries for migratory and non-migratory species. In doing so it has identified relevant data sources and developed approaches for dealing with many of the gaps and inconsistencies in the data available. The study has investigated the feasibility of developing a method for determining the risk posed, by trade, to the sustainability of commercially exploited and/or migratory species. In particular, the study has successfully applied a vulnerability, value and violability approach to assessing this risk. It is clear that, where the raw data are available, such an analysis can provide useful guidance to identification of the relative risk-level of species in trade and point to the nature of actions required to address that risk most effectively.

The study has identified a number of areas where further consideration and research is required to refine the method and review the validity of approaches adopted. Further, information on key characteristics of many species and particularly fisheries and management of these species is lacking. This in itself suggests these species could be at high risk of over-exploitation and should therefore be a focus for future investigations. Addressing data gaps and improving reliability of data may be both time consuming and expensive.

This study has effectively prioritized those species for which additional research might be a conservation priority and be most cost-effective. Key findings of the study are outlined below. Data constraints and specific aspects of the method that may warrant further consideration and refinement are also identified.

9.1 Key findings

1. The selection process resulted in 505 commercially traded and/or migratory fish species for which value and vulnerability assessments were carried out. Of these selected species, 44% were categorized as migratory and 18% were either listed or had been proposed for listing in CITES and/or listed on Appendix I and/or II of CMS.

2. The percentage of species assessed for vulnerability, value and violability at each scoring level is provided in Table 20.

Table 20. Species by category (%)

Score	Vulnerability (n=505)	Value (n=505)	Violability (n=109)
Low	41	59	14[1]
Medium	32	16	28
High	24	18	33[2]
No score	3	6	25

Note: [1] corresponds to very low and low and [2] very high and high.

3. The study has identified a set of core characteristics or attributes that should be considered in assessing vulnerability, value and violability (see Table 21). Further work could be done to refine or expand these characteristics.

Table 21. Variables used in assessing risk

Vulnerability	Value	Violability
Age at maturity—minimum (years)	Ex-vessel/landing prices	Scale of the fishery
Size at maturity—minimum (cm)	Expert judgement on species with high value commodities	Target or non-target catch
Maximum age/ longevity (years)		Fishery location
Average size—maximum (cm)		Management jurisdiction
Reproductive Strategy		Stock assessment
Fecundity (max litter size or no. of eggs)		harvest-related measures
Trophic level		Trade-related measures
		MCS measures

4. Twenty-four percent of all assessed species were identified as having a high priced commodity, which was not reflected in the ex-vessel price data used. The complexity of the trade chain and product prices has been discussed.

5. The study concluded that meaningful assessment of violability required assessment of both the rigour of management and compliance with management. Overall, the nature and extent of the management arrangements are considered to be more important as an indicator of violability than the reported level of compliance. For example, low levels of infringements can reflect poor enforcement of the management measures rather than high compliance with those measures. It is also the case that, where investment has been made in rigorous management, investment is usually protected through investment in strong MCS regimes.

6. The analysis in this study clearly points to the need to assess violability of species at the stock level rather than the species level as different stocks are subject to different management jurisdictions and regimes.

7. Based on the assessment of 505 species (derived from >1,600 taxa) assessed for vulnerability and value, and 109 species assessed for violability, the study identified 34 species at high risk of over-exploitation, 12 species at potentially high risk and eight with high violability scores. The species identified are a disparate group of species comprising finfish and invertebrates, freshwater and marine species. Management of these species varies in both nature and rigour and the species are variously managed under national, regional and international management arrangements. Fifty-two percent of these 54 species are considered migratory.

8. Sharks are heavily represented in the highest risk group with sharks comprising 17 of the 54 species (31%). This is not surprising given they have common life history characteristics that make them vulnerable to over-exploitation and generally shark fins have high value. In addition, there is acknowledged paucity of management for these species globally.

9. Of the 54 species, 23 are listed by one or both of CITES and CMS. Our analysis of the potential for CITES and CMS to address the risk posed to the remaining species revealed that:
   - CITES could provide benefits to southern bluefin tuna, Atlantic bluefin tuna, Patagonian toothfish, leafscale gulper shark, gulper shark, dusky shark, copper shark, thresher shark, porbeagle and scalloped hammerhead shark;
   - further analysis of trade is required to determine the applicability of CITES to bluntnose sixgill shark *Hexanchus griseus*, longfin mako shark and blue marlin; and
   - CMS could provide benefits to southern bluefin tuna, blue marlin and all the migratory shark species in the high-risk groups.

- CMS could help to address harvest for national consumption, by-catch as well as other non-trade related threats for migratory species and may have benefits for species such as largetooth/freshwater sawfish, narrowsnout sawfish*,* pangasid catfish and aba.

10. The application of risk-based approaches to fish species has, until now, been restricted to the analysis of the risk posed by a fishery to particular species in, or associated with, that fishery. The development of appropriate methodology to undertake those analyses has required considerable time and resources and will continue to evolve. The scope of this project is significantly broader, given that it deals with the impacts of all fisheries on species throughout their global range as well as introducing the impact of trade on the species. It is not surprising, therefore that this first iteration of the methodology has identified a range of issues that require further refinement and analysis.

9.2 Findings on data and methodology

11. It is difficult to identify species in trade at the species level because there is a lack of species identification at the catching level and this is compounded by an inadequate range of species-based trade codes. This means that the species identified in this study may not necessarily be the most commercially significant species.

12. Compiling credible information for the full suite of biological characteristics requires the use of a wide range of source materials of varying quality and of some inconsistent information. Assessment of vulnerability therefore requires some judgements to be made about the most accurate information to use. For some species, basic biological information to inform the vulnerability characteristics does not exist and this introduces considerable uncertainty into these vulnerability scores.

13. This study has applied a common set of biological criteria for assessment of a wide range of taxonomic groups. CSIRO uses the same cut-off values and biological characteristics to assess aquatic fauna ranging from marine mammals to aquatic invertebrates and it has carefully tested this methodology and produced results to suggest that it is valid for assessing productivity. Given more time and resources, it may be valuable to investigate further the validity of using a 'one size fits all' scoring system.

14. A number of other possible methods of scoring species for high risk of over-exploitation could be considered in conjunction with this methodology. For example, investigating species declines, population size, extrinsic threats, etc. as is done in the IUCN Red List could be considered. It is possible there might be ways of incorporating such information into the vulnerability assessment. Additionally, one could investigate the possibilities of using different cut-off values and the number of categories for the scoring system.

15. Consistent, species-specific value data were not available for all the species assessed and ex-vessel data were used, rather than the more ideal use of data through the trade chain. This was due to availability of information, particularly to species level. However, there are still a number of problems with landings data, including where landings are not identified to species level and the variety of products that can be derived from a species and the range of values associated with these products; making the determination of an average value at the species level extremely difficult.

16. Determination of violability is complicated for many species by the need to consider information on management and compliance at the fishery and stock level, rather than at the species level, and to then use that information, which varies in availability, credibility and comprehensiveness, to determine a violability score for the species as a whole. The scoring system requires further refinement. Further development of the methodology for

assessing violability could more closely consider the approaches used in a range of other fishery sustainability assessment processes.

17. The analysis suggests that the combination of vulnerability and the rigour of management arrangements could provide a less complex and potentially, just as informative guide to the high-risk species in trade, than the 3V approach adopted here. If additional resources were to be devoted to refining the framework, consideration might be given to focusing on these two elements because of the complexity of value data.

18. It may be useful to devise a method of incorporating the reliability scores into the scores for each of value, vulnerability and violability. Furthermore, in some circumstances, a more precautionary approach could be taken, whereby species identified as having poor reliability might be regarded as being potentially highly vulnerable and/or highly violable and would indicate that further species-specific research should be carried out.

19. False positives (misidentification of high-risk species) have been identified, resulting from a number of different stages in the current project including:

- selection of species from the FAO catch list using a number of different criteria in order to represent: the range of species in trade; CITES and CMS listed species; migratory species; and threatened species;
- the necessary use of generic data for vulnerability and value where species-specific data were not available;
- lack of species-specific data for some species;
- low reliability in the data available to score species; and,
- the need to select a sub-set of species for violability assessment, which was primarily based on high vulnerability and value.

For similar reasons, it is likely that some high-risk species have not been detected by this methodology.

20. The possibility of deriving a single overall score for a combination of the three categories (value, vulnerability and violability) could be further investigated and may be useful for identifying the **most** high-risk species. If this were to be considered, a system of weighting for the relative importance of each of the categories might be required. More work could be done to investigate the usefulness of such an approach. Even if a system were developed to do this, it would be advisable to maintain an individual score for each of the categories, to ensure that species-specific conservation issues were not missed.

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Glossary

CCAMLR	Commission for the Conservation of Antarctic Marine Living Resources
CDS	Catch Documentation Scheme
CITES	Convention on International Trade in Endangered Species of Wild Fauna and Flora
CMS	Convention on Migratory Species
CPUE	Catch per unit effort
CSIRO	Commonwealth Scientific and Industrial Research Organisation
EEZ	Exclusive economic zone
FAO	Food and Agriculture Organization of the United Nations
GROMS	Global Register of Migratory Species
ITQ	Individual transferable quota
IUCN	International Union for the Conservation of Nature
IUU	Illegal, unreported and unregulated (fishing)
LEMIS	Law enforcement Management Information System
MCS	Monitoring, control and surveillance
MEA	Multilateral Environmental Agreement
MoU	Memorandum of Understanding
NDF	Non-detriment findings (CITES)
NMFS	National Marine Fisheries Service (USA)
NOAA	National Oceanic and Atmospheric Administration
PSA	Productivity-susceptibility Analysis
RFMO	Regional fisheries management organization
TAC	Total allowable catch
TDS	Trade documentation scheme
UBC	University of British Columbia
UNFSA	United Nations Fish Stocks Agreement
UNCLOS	United Nations Convention on the Law of the Sea
VMS	Vessel monitoring system

JNCC Report
No 453 Addendum

Fish and Multilateral Environmental Agreements (MEAs): developing a method to identify high risk commercially-exploited aquatic organisms in trade and an analysis of the potential application of MEAs

Report of an expert review workshop
Aberdeen, Scotland 26 - 27 September 2011

Fleming, L.V., Goodman, G., Williams, J., Crook, V.,
Littlewood, A.H., Oldfield, T. & Sant, G.

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For further information please contact:

Joint Nature Conservation Committee
Monkstone House
City Road
Peterborough PE1 1JY

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JNCC Report No 453 Addendum

Contents

1 Introduction

1.1 Background

In September 2010, the Joint Nature Conservation Committee[1] (JNCC) commissioned TRAFFIC to develop a process of risk assessment to identify commercially exploited aquatic organisms in trade which were at highest risk of over-exploitation and to consider whether those species identified as being at highest risk would benefit from measures under Multi-lateral Environmental Agreements (MEAs), especially CITES (Convention on International Trade in Endangered Species) and CMS (Convention on Migratory Species). The approach sought to assess risk under three categories, namely the three 'Vs' of vulnerability, value and violability, (which were derived from a report appraising "*the suitability of the CITES criteria for listing commercially-exploited aquatic species"* [2]) or, in other words, ecological, economic and compliance risk. In undertaking this study, TRAFFIC identified a number of difficulties in undertaking a first iteration of the approach (see Sant *et al* 2012) and, accordingly, it was felt that it would be useful to subject the report and the approach to expert peer review which could also inform any future steps with this study. JNCC and TRAFFIC also felt such an expert peer review was warranted given the sensitive nature of determining the usefulness of a method which could potentially be used in the future to identify species in trade that may warrant higher levels of management intervention. The expert review would help ensure the method was critiqued before being released publicly for wider consideration.

Accordingly, a peer review workshop was organised and held in Aberdeen in September 2011 (for agenda see Annex A); this report summarises the outcome. Workshop participants (see Annex B) included experts from a variety of backgrounds, including fishery risk-based assessments, modelling, certification, and policy makers along with relevant TRAFFIC and JNCC staff (See Annex B); written comments were also received from the Secretariat of the FAO (Food & Agriculture Organisation of the United Nations) which were distributed to participants and introduced at relevant parts of the meeting. In addition to assessing the various risks separately and the merits of the approach collectively, approaches to risk-based assessments taken by other participants were also discussed.

1.2 Aims

The workshop aimed to enable critical expert review of a report, commissioned by JNCC from TRAFFIC; specifically it:

i. considered the validity, merit and benefit of the approach taken;
ii. critically appraised the method and data sources used for the analysis; and
iii. recommended improvements to the method and approach and how (or if) it might be taken forward in future.

1.3 Principles

The workshop participants agreed to the following principles to guide the approach taken during the meeting:

[1] http://www.jncc.defra.gov.uk/
[2] FAO. 2000. *An appraisal of the suitability of the CITES criteria for listing commercially-exploited aquatic species*. FAO Fisheries Circular No. 954. Rome, FAO.

- the meeting was held under the equivalent of Chatham House rules – comments made would not be attributed to individuals (unless specifically requested to the contrary);
- any aspect of the report or method was open to challenge and participants were encouraged to be frank in their criticisms;
- participation was not seen, and was not taken, to be giving any kind of endorsement, whether by individuals or organisations, to the approach or concept;
- individuals were invited as experts rather than as organisational representatives.

2 Workshop presentations

After an introduction to the aims of, and background to, the study, the group heard presentations from the following participants.

Will Le Quesne (CEFAS[3]) outlined an approach to conduct rapid vulnerability assessments of all fish species in a community based on life-history information and only minimal 'local' data, to support rapid risk assessments (Le Quesne & Jennings 2011). The approach was demonstrated with a case study of the Celtic Sea (in the North East Atlantic) demersal fish assemblage. Based on the assumption of equal catchability between all species the analysis was extended to consider the extent of potential trade-offs between yield and conservation objectives and to demonstrate the desire of fisheries and management to decouple the mortality applied to commercially targeted stocks and species of conservation concern.

Tony Smith (CSIRO[4]) summarised Australia's Ecological Risk Assessment for the Effects of Fishing (ERAEF).This is a hierarchical set of methods involving sequential screening (triage) of low risk activities and successive focus with more quantitative methods on higher risk species, habitats and communities (Hobday *et al* 2011). It has been applied to over 30 fisheries in Australia with over 2,000 species and 200 habitat types screened. The three stage process moved from a qualitative Scale Intensity Consequence Analysis (SICA), through a semi-quantitative Productivity-Sensitivity Analysis (PSA) to a quantitative Sustainability Assessment for Fishing Effects (SAFE) method that estimates mortality rates and associated sustainability reference points.

Wes Patrick (NOAA[5]) provided an overview of their agency's modification of the PSA with examples of its application to six of its fisheries (representing 162 stocks) in the United States (Patrick *et al* 2010). Stocks were scored against a range of indicators with data quality also being scored to avoid inaccurate assessments of risk. Additionally, an extension of the approach to deal with data poor stocks through an Only Reliable Catch Stocks (ORCS) analysis (Berkson *et al* 2011) was outlined along with Climate Change Vulnerability Assessments (CCVA).

Dan Hoggarth (MSC[6]) outlined the risk-based framework taken for data deficient fisheries being assessed for MSC certification. The approach includes a qualitative SICA and, where scores from the previous analysis warrant it, a semi-quantitative Productivity-Sensitivity Analysis (PSA). Assessments at lower levels of certainty focus on the 'main species' retained – determining these depends upon expert judgement.

Zeb Hogan (CMS Scientific Councillor) presented his approach (Hogan 2011) to identifying migratory freshwater fish that might meet the criteria for inclusion on the Appendices of

[3] Centre for Ecology, Fisheries & Aquaculture Science
[4] Commonwealth Scientific and Industrial Research Organisation
[5] National Oceanic & Atmospheric Administration
[6] Marine Stewardship Council

CMS. Using FishBase and the IUCN Red List as a starting point, 30+ species meet all criteria: migratory, transboundary freshwater fish with unfavourable conservation status. An additional 10+ species were added to this list based on information from other sources including an additional 3,000 IUCN Red List assessments (completed in 2010 and 2011), CMS scientific councillors, the Global Registry of Migratory Species (GROMS) and published primary research. This preliminary review identified several species assemblages that would probably benefit from listing on CMS. These are groups of fish that contain many threatened species, occur in areas with many transboundary issues, or both. As knowledge of this group of species is incomplete, this must be considered a work in progress and reviewed and updated regularly.

3 Workshop discussion

The following sections summarise key points made by participants at relevant stages of the review.

3.1 General comments - overview

The original analysis was seen by participants as being a valuable exercise and well worth undertaking, even though some difficulties were encountered. The workshop, as well as providing a critique of the risk assessment under review, had also stimulated participants to reflect upon their own approaches to the various productivity-susceptibility and/or risk-based analyses with which they were involved.

Participants felt that the analysis demonstrated a clear and positive convergence between methods used by fisheries management and their application to conservation management, which in turn might help with broader acceptance of the approach. The analysis, as undertaken, and with revisions to the method should feed into, and contribute to, wider discussions on the application of risk-based assessments to fisheries and conservation.

CITES and CMS differ in their aims and objectives. Accordingly, it was felt that it would be more useful to apply different approaches for each Convention rather than trying to combine them into one risk assessment. However the aim of the study was to identify commercially-exploited species of highest risk and, therefore, the initial starting point was a selection of species known to be in trade. Whilst such an approach was relevant to CITES, CMS might provide benefits as a mechanism for species regardless of whether they are in trade.

With respect to CMS, there were also, as noted in the study report, difficulties defining which species were, and were not, migratory (an issue not restricted to this analysis) and how to deal with species which were sedentary for parts of their life cycle but mobile, if not migratory, in others (e.g. corals). This difficulty is not unique to this study; the concept of shared stocks, for example, might be a better approach for marine species. However, whether a species is migratory or not is one of the two “criteria” for listing species under CMS and so cannot be ignored when investigating the applicability of that Convention to species.

The generation of lists of priority species as a final output of the process, was seen to fit uncomfortably with the original stated objective to avoid providing a ‘shopping list’ of species that may warrant consideration for listing under an MEA. In other words, any such risk assessment was, by definition, going to identify species at *potentially high risk*, a list of which might then be used to prioritise species for consideration for listing under an MEA or for other remedial measures to reduce risks. Indeed, generation of such a list of high risk species was seen by many participants as a positive and necessary output, without which it is difficult to understand and critique the process.

Participants felt that parts of the method as described in the report were insufficiently transparent such that it would be difficult for others to repeat the exercise independently. More detail on the individual steps taken was essential (perhaps through flowcharts) and it was particularly important to develop a more transparent and repeatable scoring process for 'violability', especially as this assessment involved greater use of expert judgement to determine whether management interventions were taking place and the adequacy of these. By contrast, assessments for 'vulnerability' and 'value' were based on more readily available and populated quantitative datasets making assessments simpler and less reliant on expert judgement.

The generation of 'false positives' by the method was not seen to be a weakness; the aim of the process was to provide a sifting mechanism whereby any putative priority species could be subject to further scrutiny. At each stage in the sifting process, more information is likely to be required which would then enable false positives to be removed. False negatives were of greater concern but these could be reduced by setting more precautionary thresholds (a consequence of this would be an increased number of false positives).

Finally, the introduction to the report seemed to imply that fisheries management had failed; participants felt, rather, that it was not fisheries management which had failed but it was the failure to implement and achieve compliance with recommended management. In other words it was the lack of effective governance which was largely responsible for the poor state of many of the world's fisheries.

3.2 Vulnerability

The approach to assessing vulnerability as a risk, and the number and type of biological characteristics or attributes used, had much in common with the approach taken by CSIRO, NOAA and others in identifying indicators of productivity in PSA; indeed, the approach was derived from these methods. Participants welcomed the extent to which different datasets had been used to derive as full a dataset as possible for biological characteristics.

However, it was recognised that some of the attributes used in the analysis may be correlated with others; this was supported by analyses undertaken separately by some of the workshop participants. The number of attributes used in the analysis could therefore possibly be reduced (when they correlate with others) making the vulnerability scoring process less time consuming. Reducing the number of attributes could also help overcome problems where data were more readily available for some of the attributes than for others. It would be desirable to determine which of the attributes are likely to be the most informative.

For example, the use of taxonomic class (Osteichthyes or Chondrichthyes) and maximum size (L_{max}) was proposed by one participant as a good indicator of vulnerability to mortality for fish species, although the life-history relationships applied for the L_{max} study were predominantly based on temperate shelf species and additional analysis would be desirable if this approach were extended to tropical or deep water species. Re-running the analysis using this as a single indicator might be a useful test, for fish at least, and might be tested separately between teleost and elasmobranch fish. Other participants felt that multiple indices of productivity were likely to be more reliable than individual indicators such as L_{max}.

Although both CSIRO and NOAA's approaches also included trophic level in their assessments, on reflection participants felt it was not clear why this attribute would correlate with vulnerability and the value of the use of this attribute was questioned.

Likewise, there was doubt, which is also supported by some literature (e.g. see Reynolds *et al* 2005), over the value of using fecundity as a risk factor. In the case of European eel, this species would have emerged as high risk if it had not been for its high fecundity (and other evidence suggests it is high risk). It is possible that low fecundity may indicate higher risk, but that high fecundity did not necessarily correspond to low risk (in other words, the inverse of the subsequent discussions on value – see next section). The group suggested that use of breeding strategy (information for which is generally available) or stock recruitment parameters (less likely to be available especially in data poor situations) may be more valuable as an indicator than fecundity even though information on fecundity is generally available.

With respect to age at maturity, this was considered to be a good indicator of risk of the stocks productivity or vulnerability. However, it was suggested that rather than take minimum age at maturity (used in this approach and by CSIRO), it would be better to take age at 50% maturity or, alternatively, use generation time because minimum age at maturity could be skewed by a single incorrect value or aberrant individual, whereas 50% maturity was typically based on a large number of measurements. This depends, of course, on suitable data being available.

All taxa approach vs taxonomic or other sub-sets

Most of the above considered the application of the method to fish species. However, it was clear that many of the attributes under consideration may not apply as readily to aquatic invertebrates, such as clams and corals. This gave rise to discussion over whether a ‘one size fits all’ approach to all taxa, despite the benefit of its relative simplicity, was in fact realistic (noting that the invertebrates under consideration were distributed across several Phyla).

For corals or sea cucumbers, for example, there were particular difficulties in applying the various attributes that worked well for fish. In the case of corals and sea cucumbers, other factors such as reproductive mode, dispersal and settlement / recruitment rates, colony longevity (for corals) and geographic range may be more appropriate attributes to consider, yet data on these and other attributes are limited, for corals especially. If using different attributes, different thresholds are likely to be required. Overall, it was concluded that it was probably not suitable to take a ‘one size fits all’ approach for all fish and aquatic invertebrates together.

Similarly, different approaches between freshwater and marine species might be appropriate. In the latter, over-exploitation is likely to be a major risk factor whereas, in freshwater systems, other factors, such as water extraction, diffuse and acute pollution and obstacles to migration, are likely to be of greater relevance. The current method is strongly linked to the risk of over-exploitation, which may thus be more relevant to marine species.

Applying the method to single taxonomic groups or other groupings of species may also be desirable as may analysis at stock rather than at species level. Sharks emerge as a group with a number of high risk species (and also with high commodity prices) for which good data and recent Red List assessments are available. Applying the method to such a group may enable prioritisation within groups by adjusting the thresholds to appropriate levels for that group. However, a focus on those groups with good data availability may simply result in assessing risks for species for which the risks are already known and poorly known taxa may, in fact, be at equal or greater risk (and so are perhaps more worthy of assessment). It was also noted that part of the purpose of the process was to try and pick up on the little considered species that would otherwise have been overlooked.

3.3 Value

The initial impression of using value to assess risk was positive in that it could be used as a proxy for susceptibility or exposure of a species to fisheries. However, value data were found to be: a) difficult to source and not widely available; b) generally of low reliability; c) rarely reported at a species-specific level; and d) difficult to compare, if they exist at all, as they could be derived from several different points along a trade chain (from ex vessel prices to retail). Businesses are likely to be unwilling to share price data for a variety of reasons (e.g. commercial confidentiality/taxes). Average price per kilogram is calculated on the basis of the whole fish whereas some species are targeted for specific high value parts and derivatives (or 'commodities').

Average price per kilogram was not found to be a useful indicator of value or risk. However, by contrast, individual "high commodity" prices (e.g. for caviar or shark fins) were more useful; many species with high value commodities (ca. 50%) had low value unit prices. Using an approach based on high commodity required consultation on prices with experts but this was not viewed negatively.

The group felt that it was likely that high value commodities increased the risk for those species or stocks but that the converse was not so; that is, low value did not necessarily mean low risk. Along the same lines, sudden and steep increases in price are also likely to increase risk – these may need to be flagged by some kind of 'alert' system.

If value is to be included as a factor in risk assessments, it may, therefore, be preferable to use a defined upper percentile of value/price, or change in value over time, as an indicator of high risk, rather than comparing values over ranges (such as low, medium, high).

An analysis by one participant, from a sample of data, found that there was a significant difference ($P<0.001$) between unit price figures and the likelihood of stocks being over-exploited, although this analysis was solely based on data from a single well managed jurisdiction. But the overlap in unit prices between sustainable and over-exploited stocks caused false-negatives to occur frequently (that is >20% of the time). Similar findings were observed using the overall value of the fishery. Therefore, the use of either unit prices or overall value of the fishery was not recommended by the expert reviewers as a stand-alone indicator. Further analyses could be undertaken, for example, into correlations between value and, say, prosecutions or confiscations (per unit police effort – cf. abalone in South Africa). In other words, the indicator should first be validated against the risk with which we are most concerned (for example, over-fishing).

In summary, value as a risk factor might better be included as part of the violability risk (or an all encompassing 'exposure' factor) because high value is likely to provide incentives to increase fishing effort and/or break management rules, in other words it increases the risk of non-compliance and over-fishing. Value is thus a useful complementary indicator (with the caveats above) but it does not merit being treated as a stand-alone indicator of risk.

Socio-economic issues

The need to consider socio-economic issues within value assessments was also discussed. It was considered that there were many socio-economic factors at play that were probably directly or indirectly affecting the overall risk to species and driving over-exploitation (for example, through subsidies). The group felt that socio-economic issues were part of a broader range of factors that governments considered when making management decisions on fisheries and other matters. The group agreed that these socio-economic issues were important but they should be analysed and considered separately from the current approach.

3.4 Violability

None of the participants liked the term 'violability' and thought this was best expressed in the future as 'Management and Compliance Risk' (M-Risk) or similar.

It was agreed that it was also necessary to look at the appropriateness of any management and not just to equate high levels of regulation with good management.

Violability was considered to be a more difficult risk to score than the others considered here. For example, vulnerability can be assessed at the species level; the biological characteristics of a species that increase its vulnerability generally do not change with time or location. Likewise, value data can be collated at a whole species level for those species in international trade. However, governance data vary between countries and regions and can change rapidly with time; different stocks of the same species may be subject to different management. Such data are also difficult to collate and in order to be able to assess more, or all, species fully, considerably more time and staff capacity would be required (only 109 spp. were scored in this assessment). It was noted that the availability of information skews judgements on the adequacy of management,

Furthermore, the approach to scoring violability lacked transparency and would be hard for others to replicate. Some of the scoring was necessarily subjective which could lead to legitimate criticism. Some high violability scores for species subject to management through RFMOs (Regional Fisheries Management Organisations) seemed surprising. The rationale for such scores needed either to be explained in the final report or in any future work.

An alternative approach was suggested, namely to score for 'exposure' by looking at the scale of the fishery as well as at the value (and other related factors) and then combine that score in a meaningful (weighted) way with a score for the M-Risk. This approach addresses what many of the participants recognised as the failure of fisheries management, namely the gap between scientific advice and management is often linked to a lack of political will and this is difficult to influence even through or despite MEAs. It is also difficult to score. To address these issues, six factors were suggested as being suitable for assessing the management risk:

- Is there a stock assessment?
- Are there appropriate management controls to constrain catch levels?
- Are scientific recommendations on catches adopted and implemented?
- Are there compliance measures to address IUU fishing?
- Are harvest rates reduced appropriately at low stock sizes?
- Are landings monitored?

These might each then be scored separately on a 3 or 5 point scale, where data were available (with Marine Stewardship Council data being an additional source of information for some stocks). However, one then also needs to know the extent to which any fishery overlaps with the stock (spatially and by depth). A list of prompts could be developed to inform scoring.

As this approach is aimed at determining which species are at risk of over-exploitation and, therefore, where governance can be used effectively to lower that risk, it would be best to first assess vulnerability and then exposure. This approach should identify the problems (M-Risk) with existing management and compliance arrangements (or lack thereof) for the species and hence logically draw attention to what management and compliance solutions may be used to reduce risk for a species through risk management. Another or additional option to reduce the amount of time and data needed to score these attributes is to limit the analysis to States or other entities that account for a majority of the harvest (e.g. >75%). For example, a highly vulnerable species may be wide-ranging but the majority of the harvest is taken by only two States. In such a case, only those two States would be evaluated for management and compliance risk, while the remaining States (which may number many) do not need to be evaluated.

It was questioned by some whether a score for management risk could be done at all? Analyses by some of the participants on stocks with good information found contrasting results between the effectiveness as management measures of the use of, for example, ITQs (individual transferable quotas) versus TACs (total allowable catch). Regardless, the best indicator of management performance was at a regional level and this may be the best basis on which management risk should be assessed.

However, because of the difficulties identified above, M-Risk could be conducted as a secondary step subsequent to the vulnerability/productivity and exposure assessments. It was further suggested that each step should be conducted in turn with the outcomes of each step being independently reported. While the vulnerability assessments will remain generally static, and are essentially globally applicable, the other steps (exposure and M-risk) are spatially and temporally variable and are also more resource intensive to undertake (that is, it is harder to find the relevant information). Thus the vulnerability assessment could be conducted as a one-off global exercise, with risks that will remain largely unchanged, but other factors (exposure and M-risk assessments) may change spatially and temporally (e.g. on a regional basis) and so could be assessed (and subsequently updated) as required or as opportunities allowed.

It was suggested that FAO's overall assessments of fisheries (whether fully exploited etc.) could be used to validate any regional assessments. Likewise, the IUCN Red List assessments, where available, could also be used to validate any approach, although in the study under review they were used in the initial selection criteria. However, it was noted that one aim of this risk assessment is also to identify those species not already known to be at risk.

In the report, it was not clear that in the final stage of the analysis, only a proportion of species were assessed against the violability criterion. The report should make it clear that the final analysis was done on only a sub-set of the overall data, which might then explain why, for example, only one sturgeon emerged as a high risk species (because not all sturgeon were assessed). The ultimate goal would be to apply the method to all species and the report simply presents a test of its application.

3.5 Data sources

A number of issues relating to data sources, gaps and how to deal with uncertainty were addressed within the discussions on the specific risk attributes. However, some additional points emerged.

It was felt that information was increasingly being collated globally on fisheries management and this may become publicly available in time. This exercise had itself contributed to the greater availability of such information (with the main dataset to be made available through the JNCC website). However, as noted above, management may change rapidly and one-off assessments quickly become out of date. How to interpret management data is also contentious.

It was felt that a more harmonised approach to the collection of data globally would enable future assessments, such as these, to be done more readily. However, it was not clear where or what the final repository of such data should be - FAO was suggested as a possible option.

It was suggested that the FAO's FishFinder publications were a more comprehensive source of information on commercially exploited aquatic organisms (with detailed information on 8000 species, >10 times as many as FAO factsheets) than FishBase & CSIRO data (which were used as a source for much of the data regarding the biological characteristics used in the vulnerability assessment). However participants noted that FishFinder was not an open access source of information, nor were its data available in the form of a database. One participant noted that FishBase correlated well with other data sources with few outliers and thus seemed a reliable source of information.

4 Conclusions

Participants were asked to summarise their views on the process and identify the most appropriate next steps. Their combined views are as follows.

The workshop, and original analysis, was seen as being a valuable first step to assessing species at risk from commercial exploitation globally; further, the analysis had enabled participants to share their own approaches to various productivity-susceptibility and/or certification analyses and to identify areas where these could collectively be improved.

There was a clear and positive convergence between methods used by fisheries management and their application for conservation management which might then reduce political sensitivities. Nevertheless, it was recognised that the subject of suggesting high risk species, which might then be considered as candidates for listing under MEAs, was politically sensitive. Some participants felt that once the method had been refined and tested further, it should be applied with the aim of identifying potentially high risk species (a 'shopping list') which might be subject to further measures to reduce the risks – whether through fisheries management and/or MEAs.

Nevertheless, the development and application of the original method has identified areas that could be improved, even if the issues were ones of fine tuning. The process needs to be made more transparent and hierarchical/step-wise in its approach – beginning with an assessment of vulnerability (i.e. a measure of sensitivity and resilience) and then followed with an assessment of exposure that measures management and compliance risk. To make this process explicit, it is recommended that the use of a flow-chart and better explanation of how attributes are scored (so that the process can be repeated by others) be provided. This two step process allows lower risk species to be eliminated making subsequent management and compliance analyses less onerous, especially as the latter are more difficult to assess and would need to be re-assessed more regularly. Additionally, trend analyses (e.g. from trade data) could be used to flag changes in risk.

The range of vulnerability and value attributes which are assessed should be re-considered and tested to see which are correlated with one another and which are correlated with wider outcomes (e.g. over-fishing). For example, maximum length could be used as indicator of vulnerability within a species group or ecological guild (e.g. elasmobranchs, shelf teleosts, deepwater teleosts etc). Within these or other (taxonomic) groups, different thresholds might be needed. It is likely that invertebrates need to be addressed separately from fish and require different sets of attributes and thresholds.

The approach as originally conceived (the three Vs) was more appropriate for assessing the benefits from CITES and, indeed, resulted from discussions on CITES listing criteria. However, future analyses with respect to identifying species which might potentially benefit from CMS needed a different approach and the starting point of identifying species in international trade should be amended to focus specifically on migratory species.

Next steps suggested by the group included, subject to available resources, applying and testing the refined method (and variations on it) on a smaller sub-set of species, perhaps specific taxonomic groups or ecological guilds. These case studies could test different approaches to scoring and use different attributes to build as robust an approach as possible. The revised method could then be applied to larger datasets.

It was agreed that for the purposes of refining the three "V" approach to risk assessment the first step should assess vulnerability, and move the value assessment into an overarching exposure assessment that also includes management and compliance risk. This would then broadly form a two-step risk assessment. As part of the exposure assessment, management solutions may inherently become obvious as tools to lower risk and the reporting of these during this process may inform well any risk management process (Figure 1).

If the full risk assessment and risk management process for a number of species was to be conducted, but constrained by time, one option could be to assess vulnerability and then take the highest risk species from that assessment through an exposure assessment and the highest risk species from that assessment would give you the overall species at highest risk. These would then form a smaller group of species at highest risk that could be taken through a risk management process (Figure 1).

It was agreed that the results of this workshop should be written up and annexed to the JNCC report produced by TRAFFIC; any future work should make the method more transparent and take account of other relevant comments from the peer review. Participants will be given the opportunity to comment on the draft workshop report.

It was also agreed that a short paper reporting the outcome of the study and workshop, with the participants as co-authors (if they wished), would be a good means of getting this work into the peer-reviewed literature. JNCC will look at options for obtaining resources to take this forward along with testing the revised method through case studies.

Finally, participants also discussed how the work might best be presented externally, noting that the focus of the work was on testing a method for a risk assessment and that it did not automatically mean that any species identified as being of high risk would, or should, be candidates for listing by an MEA, rather that this was a means of narrowing the focus to help judge where MEAs might complement fisheries management.

5 Acknowledgements

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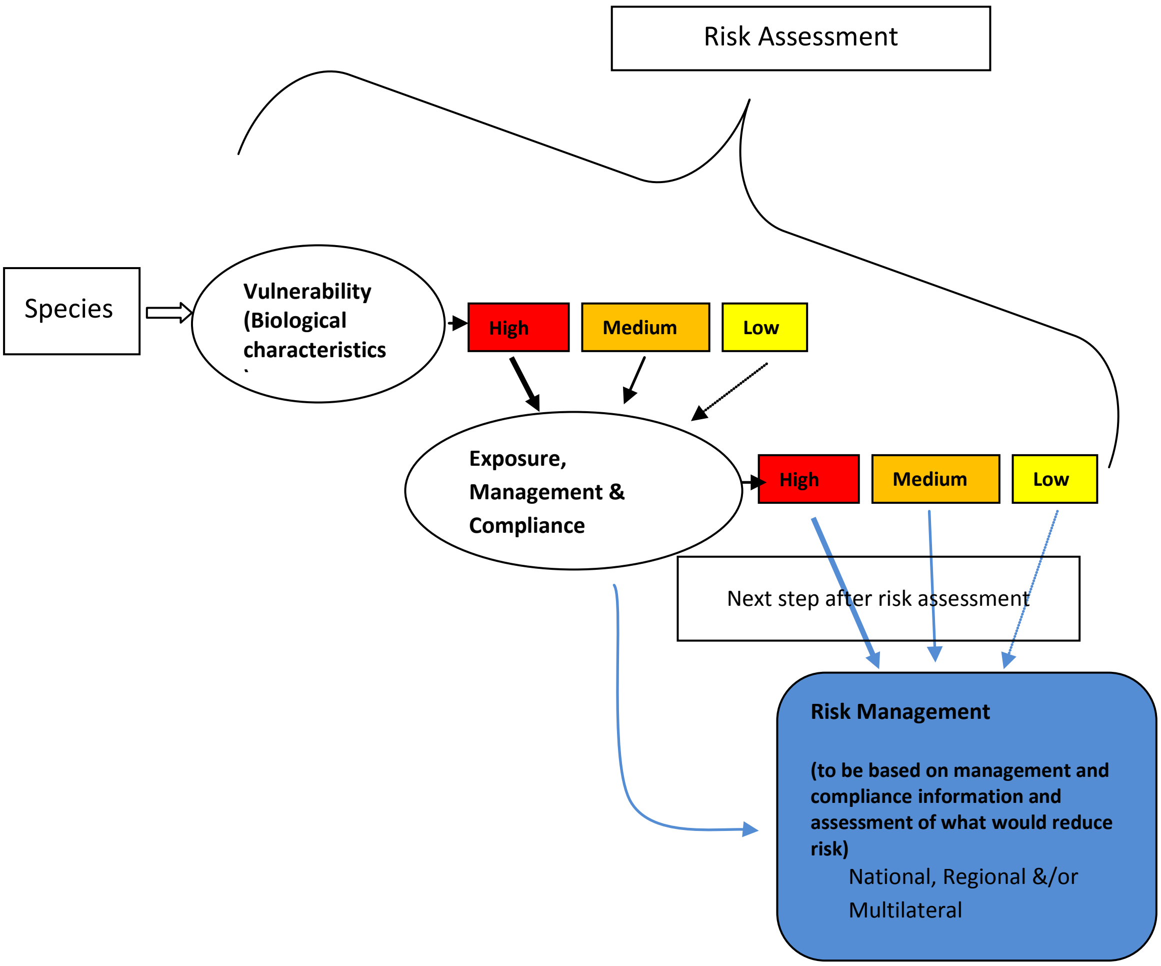

Figure 1: Suggested steps in risk assessment and management decision making processes

Annex A Workshop programme

Day 1 (Chair: Mark Tasker, JNCC)

0930 Welcome – Mark Tasker

0940 Purpose and objectives of the meeting, general principles and background – Vin Fleming (JNCC)

1000 Fish & MEA review – TRAFFIC (Thomasina Oldfield, TRAFFIC)

1045 COFFEE

1100 Other risk-based approaches to fisheries and their relevance

- Will le Quesne (CEFAS) - *Predicting conservation reference points and species vulnerability with minimal data to support rapid risk assessment of fishing impacts on biodiversity and associated management tradeoffs*
- Tony Smith (CSIRO) - *Ecological Risk Assessment for fisheries in Australia*
- Wesley Patrick (NOAA) – *NOAA Fisheries Vulnerability Assessments: PSA, CCVA, and ORCS*[7]
- Dan Hoggarth (MSC) - *Risk Based Framework for MSC data deficient fisheries*
- Zeb Hogan (CMS Scientific Councillor) – *CMS review of migratory freshwater fish*

1300 LUNCH

1400 Assessment of the approach overall – general discussion on validity, merit, risks and benefits – lessons from other approaches

1530 COFFEE

1545 Value (economic risk) – issues associated with assessing this risk (Vicki Crook, TRAFFIC)

1700 Close – day 1 – brief resume of progress on the day

Day 2 (Chair: Vin Fleming, JNCC)

0900 Vulnerability (biological risk) – issues associating with assessing this risk (Gemma Goodman, TRAFFIC)

1045 COFFEE

1100 Violability (compliance risk) – issues associated with assessing this risk (Glenn Sant, TRAFFIC)

1245 LUNCH

1330 Other issues including: Taxonomic sub-sets versus an ‘all taxa’ approach

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[7] PSA - Productivity Susceptibility Analysis, CCVA - Climate Change Vulnerability Assessment, and ORCS - Only Reliable Catch Stocks

1430 Data sources – dealing with gaps, quality, reliability and uncertainty

1530 COFFEE

1545 Next steps and conclusions - identify key improvements to methodology and discussion on outputs

1645 Summing up

1700 Close

Annex B Workshop participants

Name	Organisation	Contact email
Zeb Hogan	Convention on Migratory Species (CMS) - Scientific Councillor	zebhogan@hotmail.com
Dan Hoggarth	Marine Stewardship Council (MSC)	Dan.Hoggarth@msc.org
Wesley Patrick	National Oceanic & Atmospheric Administration (NOAA)	Wesley.Patrick@noaa.gov
Will le Quesne	Centre for Environment, Fisheries & Aquaculture Science (CEFAS)	Will.LeQuesne@cefas.co.uk
Tony Smith	Commonwealth Scientific and Industrial Research Organisation (CSIRO)	Tony.D.Smith@csiro.au
Gael de Rotalier	European Commission	gael.de-rotalier@ec.europa.eu
Vicki Crook	TRAFFIC	Vicki.Crook@traffic.org
Gemma Goodman	TRAFFIC	Gemma.Goodman@traffic.org
Thomasina Oldfield	TRAFFIC	Thomasina.Oldfield@traffic.org
Glenn Sant	TRAFFIC	glenn.sant@traffic.org
Tom Blasdale	Joint Nature Conservation Committee (JNCC)	tom.blasdale@jncc.gov.uk
Vin Fleming	JNCC	vin.fleming@jncc.gov.uk
Alison Littlewood	JNCC	alison.littlewood@jncc.gov.uk
Mark Tasker	JNCC	mark.tasker@jncc.gov.uk
James Williams	JNCC	james.williams@jncc.gov.uk