FAO Fisheries Circular No. 954 **FIRM/C954(En)**
ISSN 0429-9329

AN APPRAISAL OF THE SUITABILITY OF THE CITES CRITERIA FOR LISTING COMMERCIALLY-EXPLOITED AQUATIC SPECIES

AN APPRAISAL OF THE SUITABILITY OF THE CITES CRITERIA FOR LISTING COMMERCIALLY-EXPLOITED AQUATIC SPECIES

FOOD AND AGRICULTURE ORGANIZATION OF THE UNITED NATIONS
Rome, February 2000

PREPARATION OF THIS DOCUMENT

This draft document, on the listing criteria used by the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES) to protect from extinction the aquatic species exploited by fisheries, has been prepared by the FAO Secretariat, assisted by FAO consultants R. Mahon, J. Pope and J. Rice as a basis for consideration of the issue by the FAO Committee on Fisheries (COFI). The document will be extensively reviewed at a special FAO Technical Consultation (in mid-2000) before being submitted to COFI (in March 2001). It will also be sent to CITES for advanced information and consideration in its own process of review of the listing criteria. The funds for the preparation and printing of this document were provided by the Government of Japan through the project GCP/INT/715/JPN.

FAO.
An appraisal of the suitability of the CITES criteria for listing commercially-exploited aquatic species.
FAO Fisheries Circular. No. 954. Rome, FAO. 2000. 66p.

ABSTRACT

The document reviews the characteristics of exploited aquatic organisms in relation to the risk that they may become extinct. This includes a review of case histories of species that have become extinct, or are at high risk, and of regions which have suffered loss of biodiversity. Life-history attributes, habitats of aquatic species and the characteristics of the fisheries that exploit them are considered. Approaches to assessing risk employed by various groups of experts are considered. The contrast between approaches used to assessing risk for terrestrial species and those used for aquatic species are highlighted. The document also contains an overview of the spectrum of fisheries and ecosystem management and conservation institutions and tools in order to illustrate the overall context in which the CITES criteria will have to operate. Finally, the report provides a detailed evaluation of the applicability of the CITES listing criteria, definitions, guidelines, etc. to exploited marine species.

The FAO Fisheries Circular is a vehicle for distribution of short or ephemeral notes, lists etc., including provisional versions of documents to be issued later in other series.

CONTENTS

1 INTRODUCTION 1
1.1 Background 1
1.2 About this document 2
2 EXTINCTION RISK FOR AQUATIC ORGANISMS 3
2.1 Diversity in ecological attributes of aquatic organisms 3
2.2 Diversity in aquatic habitats 5
2.3 Diversity in types of fisheries 5
2.4 Single species and multispecies fisheries considerations 7
2.5 Review of the literature on species extinctions and risk 8
2.6 Assessing risk of extinction of aquatic species 14
2.7 Summarising contrasts between fishes and aquatic invertebrates and terrestrial vertebrates 16
3 THE CONTEXT OF CITES IN MARINE CONSERVATION SYSTEMS 18
3.1 Institutional arrangements to promote marine conservation 18
3.2 Objectives and techniques of fisheries and ecosystem management 21
3.3 Species for which CITES listing is a priority 26
4 EVALUATION OF CITES CRITERIA WITH RESPECT TO THEIR APPLICABILITY TO EXPLOITED MARINE SPECIES 32
4.1 Approach to the evaluation 32
4.2 The Criteria dealing with Trade 33
4.3 Consideration of Criterion A 35
4.3.1 Statement of Criterion 35
4.3.2 Points to note from the definitions 35
4.3.3 Evaluation of the Criterion 35
4.4 Consideration of Criterion B 37
4.4.1 Statement of Criterion 37
4.4.2 Points to note from the definitions 37
Area of distribution 37
Fragmentation 38
4.4.3 Evaluation of the Criterion 38
4.5 Consideration of Criterion C 39
4.5.1 Statement of Criterion 39
4.5.2 Points to note from the definitions 39
4.5.3 Evaluation of the Criterion 39
4.6 Consideration of Criterion D 41
4.6.1 Statement of Criterion 41
4.6.2 Points to note from the definitions 41
4.6.3 Evaluation of the Criterion 41
4.7 Criteria for Appendix II listing under Article II Paragraph 2a of CITES 41
4.7.1 Statement of Criterion 41
4.7.2 Evaluation of the Criterion 42
4.8 Criteria for Appendix II listing under Article II Paragraph 2b of CITES 42
4.8.1 Statement of Criterion 42
4.8.2 Evaluation of Criterion 43
4.9 Issues regarding split-listing and higher taxa 44
4.10 Issues regarding precautionary measures 44

4.11 Issues regarding definitions 44
4.12 Concordance of IUCN and CITES Criteria 45
5 POPULATIONS AND SUBPOPULATIONS 46
6 FISHERIES BIOLOGICAL REFERENCE POINTS AND RISK OF EXTINCTION 47
7 KEY CONCERNS AND CONCLUSIONS 48
8 REFERENCES 49

Annex 1: A summary by class, order and family of the species listed on the 1996 IUCN red list by category 54
Annex 2: Concordance of CITES and IUCN listing criteria 57
Annex 3: Biological criteria for listing species in CITES Appendix I (as provided in CITES COP 9.21, 1994, Annex 1) 59
Annex 4: Suggestions for rewording of biological criteria for listing species in CITES Appendix I 60
Annex 5: Definitions, notes and guidelines as provided in CITES COP 9.21, 1994, Annex 5 62
Annex 6: Glossary 65

1 INTRODUCTION

1.1 Background

The purpose of CITES is to address and attempt to reduce risk, in terms of probability of species extinction, through restrictions on trade. This is achieved through the listing of species considered to be threatened with extinction, according to specified criteria. Species may be listed in any of three Appendices. For species listed in Appendix I, trade is banned. For those listed in Appendix II trade is possible only with certifications and permits. Appendix III listings are voluntary by countries that are seeking international support in controlling trade in species of concern to them.

Until the early 1990s, CITES listing was primarily of species other than exploited aquatic fishes or invertebrates. Through the 1990s, attempts to list exploited marine fishes raised questions regarding the appropriateness of the listing criteria for these species.

Attention to the applicability of listing criteria for marine species in CITES has been paralleled and informed by the recent attention of IUCN to the appropriateness of their criteria for listing fishes (Hudson *et al* 1997, Issac and Mace 1998, Mace 1999). The IUCN has been a primary source of technical input into the CITES process of developing and adopting criteria. At the 8th CITES Conference of Parties in Kyoto, Japan, IUCN was tasked with preparing a working paper on the criteria, definitions and guidelines for listing species in the CITES Appendices, for consideration at the 9th CITES Conference of Parties in Fort Lauderdale, USA. The 9th CITES COP, discussed and revised the IUCN proposals and adopted revised listing criteria, definitions and guidelines.

During the 10th session of the CITES Conference of Parties (COP 10, Harare, Zimbabwe) a proposal was tabled for the creation of a Working Group for Marine Species to address the concern that some fish species exploited on a large scale and subject to international trade might qualify for being listed in CITES annexes. Concern was however also expressed that the general CITES criteria might not be appropriate to deal with exploited and managed fishery resources. The concern was brought to the attention of the COFI Sub-Committee on Fish Trade in Bremen (Germany, June 1998), where "*South Africa proposed that FAO should be asked to appoint an ad hoc group to make suggestions on how such a process of scientific review might best be pursued, leading perhaps to proposals for amendment to and/or appropriate interpretation of the CITES criteria in the context of marine fish species under large-scale commercial harvest.....The proposal was strongly supported and subsequently adopted..*".[1]

The *ad hoc* group met in Cape Town on 20 November 1998, in accordance with the request from the COFI Sub-Committee on Fish Trade for FAO to initiate a scientific review of the current CITES criteria for Appendix I and II listings in the context of marine species under large-scale commercial harvest.

The purpose of the meeting was to enable the FAO Secretariat to obtain technical and scientific views on the proposal from a range of experts in the field so that it could prepare an

[1] Report of the Sixth Session of COFI Sub-Committee on Fish Trade, Bremen, Germany, 3-6 June 1998. Para. 12 and Appendix F

appropriate information paper on the issue to submit to COFI 1999 for its consideration. As a consequence, the meeting:

- studied the proposal made by the COFI Sub-Committee on Fish Trade to initiate the scientific review; and
- suggested steps for an in-depth scientific review of these criteria in this context, where the products of such a review could include, if considered necessary, proposals for amendments to and/or appropriate interpretations of these CITES criteria.

The locality and timing of the meeting enabled the FAO to collect, informally, some scientific views on the problem, taking advantage of the presence of many relevant experts at the ICES Symposium on Confronting Uncertainty in the Evaluation and Implementation of Fisheries Management Systems (Cape Town, South Africa, 16-19 November 1998). A total of 14 technical experts participated in the meeting, in addition to a representative from the CITES secretariat, and two members of the FAO Secretariat.

At its 23rd Session, held in Rome in February 1999, the FAO Committee on Fisheries (COFI) endorsed the report of the consultation of the FAO *Ad hoc* Expert Group on Listing Criteria for Marine Species under CITES (FAO 1998) and agreed with its recommendations regarding the approach to reviewing the listing criteria. As regards the timing of its proposed work, it was indicated that it was necessary to inform in a preliminary fashion the Eleventh Session of the Conference of Parties to CITES of this work. Some delegations expressed the view that in reviewing the CITES listing criteria, FAO should take due account of the relevant provisions of UNCLOS relating to living marine resources.

In response to this request, the FAO Secretariat, assisted by three consultants, addressed the issues raised in the Report of the meeting of the FAO *Ad hoc* Expert Group on Listing Criteria for Marine Species Under CITES, and prepared the present document as a working paper to be considered at an open expert consultation on this topic in 2000. Together with the reports of the Cape Town meeting and COFI, the working paper may be submitted to the CITES Conference of the Parties (COP) 11, as preliminary information on the FAO process.

1.2 About this document

This report begins by reviewing in Section 2 the characteristics of exploited aquatic organisms particularly as these characteristics relate to the risk that they may become extinct. This includes a review of case histories of species that have become extinct or at high risk, and regions which have suffered loss of biodiversity. Life-history attributes and habitats of aquatic species and the characteristics of the fisheries that exploit them are considered. Approaches to assessing risk taken by various groups of experts are considered, particularly in contrast to terrestrial species.

The report continues in Section 3 with an overview of the spectrum of fisheries and ecosystem management and conservation institutions and tools. This is done to provide a context for consideration of the unique role of CITES in conserving aquatic species.

Finally, in Sections 4 and 5, the report provides a detailed evaluation of the CITES listing criteria, definitions, guidelines, and related issues with respect to their applicability to exploited marine species.

2 EXTINCTION RISK FOR AQUATIC ORGANISMS

Aquatic species vary considerably with regard to many life-history and other ecological attributes that would be expected to affect their vulnerability to extinction. The characteristics of their habitats, and in the case of harvested species, the fisheries that exploit them, also affect the vulnerability of aquatic species to extinction from a variety of causes. The diversity of life-histories, habitats, and patterns of exploitation present many conditions which are rare or absent among terrestrial animals. Therefore, criteria which might lead to robust and efficient evaluations of risk of extinction for birds and mammals, could break down when applied to species with very different life-history attributes, exploited in ways rarely encountered in terrestrial vertebrate populations. Reviewing the diversity of attributes of aquatic organisms is helpful in understanding the different types of problems encountered when attempting to evaluate their true risks of extinction.

There is undoubtedly a great deal of interrelation among these attributes, but for ease of summary, they are considered in three categories below. Whereas, the primary concern is with populations of aquatic organisms exploited by conventional capture fisheries, it is worth noting that if exploitation of fishes for the bait and aquarium trades is considered, species from the full range of ecological attributes are potentially exploitable. Therefore, it is useful to be inclusive in considering the implications of these attributes.

2.1 Diversity in ecological attributes of aquatic organisms

The wide range of life-history and other ecological characteristics of aquatic organisms has considerable implications for assessment of their vulnerability to extinction. Fishes range in adult body size from less than 1 cm to over 10 m in length. Life-history styles, even within the same ecosystem, range from early maturity, high fecundity and low parental care to the opposite set of characteristics (Balon 1975, Breder and Rosen 1966). Inclusion of marine mammals and sea turtles in the spectrum of aquatic animals to be considered broadens the range of life-history characteristics towards the larger sizes and more complex reproductive strategies, and provides cases more similar to terrestrial mammals and birds, where the CITES criteria have been applied most often. Inclusion of marine invertebrates, however, broadens the range of life-history characteristics towards smaller sizes, and sometimes very complex multi-staged life-history and reproductive strategies.

Mating strategies of fishes and elasmobranchs vary from internal fertilization (sharks, rays, cyprinodontids) through pair spawning (the majority of species) to group spawning (schooling species), sometimes in large spawning aggregations (notably groupers, Sadovy 1997, Johannes 1997). Simultaneous hermaphrodites occur, though infrequently. Sequential hermaphrodites are common, most often in systems with numerous females breeding with a single terminal male. In these systems (e.g. in groupers and wrasses), the removal of the male triggers a sex change in one of the larger females (Breder and Rosen 1966).

The majority of species, primarily those with numerous small eggs, do not exhibit any form of parental care. In species where it occurs, parental care includes the full range of activities: egg hiding; guarding and tending eggs on open substrates; nest construction, guarding and tending; mouth and pouch brooding; and live-bearing. In species with high individual investment in individual offspring, protective mechanisms may include egg cases and elaborate hiding strategies (Balon 1975).

Distribution ranges of marine animal populations and subpopulations vary from inter-oceanic, e.g. dolphinfish, great white shark, to highly localized in a single bay.

Patterns of movement also vary from inter-oceanic migration (e.g. billfishes), to highly sedentary (e.g. conch, abalone) and even sessile (e.g. black corals, attached bivalves). For fishes, the migratory paths are seldom known with any degree of accuracy, except for the most valuable and visible species. Even for Atlantic yellowfin tuna, the migratory path remains a hypothesis and the subpopulation structure used for management continues to be debated. This is in sharp contrast to the migratory paths for most terrestrial animals, which are generally well documented.

The aquatic medium presents opportunities for passive dispersal over long distances of early life-history stages that have little capability for active migration. This opportunity is frequently incorporated into life-histories of aquatic organisms, particularly in marine conditions. It serves to broaden the range over which recolonisation may take place as well as to decrease the probability of genetic isolation of subpopulations that may be separate as adults. Most terrestrial animals do not have comparable opportunities for passive dispersal, but plants do, through adaptation to wind dispersal.

The wide distribution ranges, extensive migrations and opportunities for passive dispersal of many species frequently result in complex subpopulation situations which are seldom well known. In fisheries, these are generally referred to as stocks. For example, in Caribbean spiny lobster, adults are restricted to reefal shelf and slope habitats that occur in distinctly discrete units throughout the region. The long planktonic larval life-history (4-6 months) presents the opportunity for exchange of recruits between adults stocks. Recent arguments about the importance of larval transport have emphasised the role of small-scale circulation in retaining recruits in natal stock areas (Boehlert 1996). Thus, after considerable research, the issue of whether there is one pan-Caribbean lobster stock or many separate stocks associated with major habitat patches remains unresolved . This lack of clarity also prevails for other species with planktonic early life-history stages, e.g. reef fishes, conch, sea urchins. Again, by contrast, for most terrestrial animals answers to these types of questions are relatively well documented.

Most aquatic animals are cold blooded (poikilothermic) and grow continuously throughout their lives (indeterminate growth). This has implications regarding the extent to which the ecological role of the animal in its ecosystem may be significantly different at different stages in its life-history (ontogenetic niche differentiation). These properties may not affect directly how risk of extinction varies with numbers of mature individuals. However, they create the opportunity for there to be different threats to marine species at different life-history stages, making the application of criteria invoking "threats from extrinsic factors" much more complex than for terrestrial vertebrates.

The complexity of interpretation of such criteria with regard to ontogenetic niche differentiation is profound. On the one hand, it could be argued that the ecological differences among the life-history stages of a marine organism should be viewed as a property which increases vulnerability through exposing species to a wider range of risks (e.g. of habitat destruction). On the other hand it can be argued as being a property which increases resilience through allowing reservoirs of a species to persist in a greater diversity of places. Where a habitat is destroyed permanently, such as clearing a coastal mangrove forest or diverting a river, many more types of aquatic species than terrestrial species may be put a risk, because a greater diversity of species may use the habitat at some point in their life-history. However a stochastic

environmental event which renders a habitat temporarily unsuitable may pose less of a threat for aquatic than terrestrial organisms, because of the existence of reservoirs of aquatic animals in other life stages and habitats.

The capacity of fishes to respond to reduced abundance due to exploitation with increased growth, and earlier maturity (density-dependence) gives marine species some resilience to exploitation; and is a fundamental component of most theory of fisheries population dynamics (Jennings *et al* 1998). In particular those with high fecundity have a particular ability to withstand high exploitation levels. Terrestrial vertebrates show less ability in these traits, but combined with variation in offspring production (clutch or litter size), generally show some opportunity for density-dependence in population dynamic processes (Emlen 1992).

2.2 Diversity in aquatic habitats

Aquatic habitats vary widely in characteristics that have considerable implications for vulnerability to extinction of the species that inhabit them (Angermeier 1995, Leidy and Moyle 1998. Powles *et al.* in press). Key among these characteristics are:

- size (area and depth), as it relates to the probability that the inhabitants will be extirpated by a localized event;
- exposure to habitat disturbance by human activities that may result in habitat destruction and pollution; and
- degree of habitat fragmentation and isolation from other similar habitats from which recolonisation might take place.

Aquatic habitats can be perceived as presenting a continuum with regard to these characteristics, in which shallow stream headwaters and ponds will present the smallest habitat units with the greatest degree of exposure to disturbance and isolation. The deepest and most offshore habitats in the ocean represent the other end of the continuum. In general, marine habitats will tend to be larger, less isolated and less exposed to disturbance than freshwater ones. However, there is a great degree of overlap between freshwater and marine habitats in these attributes, particularly in regard to human impacts in near shore and coastal marine habitats, and even enclosed seas.

Another characteristic that roughly parallels the above continuum is the probability that a habitat will support populations that can sustain commercial fishing. For a given set of life-history attributes, population and subpopulation sizes can be expected to be positively correlated with habitat size, a factor which can be considered directly in evaluating the threat posed by exploitation of specific populations and subpopulations.

2.3 Diversity in types of fisheries

There is a great deal of diversity in the way that aquatic resources are exploited, although these present a continuum. Various schemes of classification for fisheries have been proposed, and it is useful for discussion purposes to consider the following categories: large-scale commercial/industrial; small-scale commercial/artisanal; and subsistence. Strictly speaking, virtually all fisheries are commercial, as there are very few fisheries for which none of the catch is traded (or bartered) in any way.

A large proportion of the world's fish catch is landed by large-scale commercial fisheries (also referred to as industrial fisheries) from a relatively small number of stocks or

subpopulations. Hence they target widely distributed, abundant populations. These fisheries are highly mechanised, use large technologically sophisticated vessels and equipment and often involve on-board processing. This category is exemplified by fisheries for:

- wide-ranging, oceanic, large pelagic species, typically using longlines, purse seines etc.;
- demersal fishes of highly productive shelves and slopes, typically using trawls;
- schooling small pelagics such as clupeoids and mackerels of highly productive upwelling and river outflow affected systems, typically using purse seines or pelagic trawls; and
- shrimps of tropical river outflow affected shelves, typically using trawls.

These are the types of fisheries on which the greatest research efforts have been expended, for which the greatest quantities of data are available and thus which should be best understood. Management tools and processes are also usually best developed for these fisheries. These have developed first in the developed countries but, since the early sixties, they have spread in the developing world as well, either as locally-based fisheries or through access agreements with long-range fleets.

Modern small-scale commercial fisheries exploit many of the same stocks as are exploited by the large-scale commercial fisheries, but also exploit a vast number of smaller stocks. They may also be mechanised, and even technologically sophisticated. This category is exemplified by fisheries for:

- deep demersal fishes of tropical shelf slopes, typically using nets, lines and traps;
- coastal large pelagic fishes, typically trolling or with small-scale longlines;
- coastal demersal fishes of temperate shelves and fiords, using traps, nets, and longlines, often exploiting the same stocks as large-scale trawl fisheries operating further offshore, but frequently targeting different life-history stages;
- small-scale fisheries for schooling small pelagics, using smaller vessels and nets than in the large scale equivalent.

Traditional artisanal fisheries exploit many of the stocks exploited by the commercial fisheries described above, and also exploit an even larger variety of very small stocks. These fisheries may be mechanised but tend to use traditional fishing gears such as small nets, traps, lines, spears and hand collection methods. This category is exemplified by fisheries for:

- fishes and invertebrates of coral reefs, typically with traps, spears, lines and by hand;
- fishes and invertebrates of coastal lagoon and estuaries, typically using nets;
- stream and river fisheries; and
- fisheries for aquarium species in all habitats.

The small-scale fisheries tend to be particularly conspicuous in tropical, less developed areas, as well as inland and are more difficult to manage. However, they are also common and sometimes as poorly understood in developed countries. The total value (as distinct from unit value) of the smaller stocks they exploit may not be sufficient to warrant effective information collection and management systems.

Small-scale fisheries are common in coastal and tropical areas of the world where biodiversity is highest and tend to exploit the whole spectrum of species available, with a wide variety of fishing gear and practices, thereby harvesting a greater variety of species than the larger and more specialised commercial fisheries.

The type of fishery may have implications for the risk of extinction of the exploited species.

- Large-scale commercial fisheries generally exploit large stocks of widely distributed species in productive areas. Data tend to be more easily collected and, as a consequence, these are frequently species for which the largest amount of information is available and for which population and ecosystem dynamics have been most studied. In most cases there are data that will allow a quantitative assessment of the status of the species in relation to CITES listing criteria, with some estimate of the assessment reliability. These fisheries are generally under established operational management systems aiming at keeping the stock at optimal level and, by implication, well above the level at which the risk of extinction (*senso strictu*) reaches any significance, even if these have very often failed to prevent overexploitation. Under these conditions, trends in stocks will tend to be monitored and situations of concern could be detected early.
- Small-scale commercial fisheries may also be well documented, particularly when they exploit stocks that also support large commercial fisheries, and thus receive particular attention from the scientists and managers. Many if not most small-scale fisheries (from commercial to subsistence), however, are poorly documented and controlled through weak or non-existent management systems, particularly when pre-existing traditional (community-based) management systems have collapsed. In these situations of unmonitored and uncontrolled exploitation, and even though data tends to improve when the products from these fisheries enter international trade, the data for assessing the status of the stocks for management as well as for applying CITES listing criteria will be poor or absent In addition, for the same reasons and with a few exceptions, such as seahorses and some aquarium trade species, the species of these fisheries do not attract a great deal of attention from conservationists and thus tend to have a lower public profile than some of the more visible species.

2.4 Single species and multispecies fisheries considerations

In the following situations that occur with regard to the numbers of species that are targeted, landed and traded by individual fisheries, it is the element of trade that is of particular concern in the present context.

i. Target single species and catch little or no bycatch (e.g. North American lobster trap fisheries, diving fisheries for conch, abalone, sea urchin, purse seine fisheries for monotypic schooling species, selective aquarium fish fisheries).

ii. Target one or more species and take a bycatch that is of insufficient or no value to be landed (e.g. finfish bycatch in some shrimp or cephalopod fisheries);

iii. Target one or more species and catch bycatch that is landed and may be traded internationally.

iv. Target an entire assemblage of species all of which are of value and may be traded (e.g. trap and net fisheries for coral reef fishes, tropical shelf finfish).

In case (i), only the target species is negatively affected by the fishery. Therefore, trade controls are likely to prevent or reduce exploitation and can be effective as a means of reducing the risk of extinction.

In case (ii), trade controls will be effective only for the target species as the non-target species are not traded, and CITES does not extend to controlling trade in targeted species to conserve non-targeted species that are endangered by fishing the target species.

In case (iii), trade controls can be used to reduce the risk of extinction for both target and non-target species. However, if the trade controls are imposed due to a non-target species, the likely response in the fishery will be to discard it at sea, retain it for domestic sale or keep it for personal consumption. If it is discarded at sea, the effect of the ban will depend on the extent to which there is survival of discarded species. This can vary from zero to almost 100% depending on the nature of the fishery (Alverson *et al*. 1994).

Case (iv) is similar to case (iii) in regard to the efficacy of trade bans but differs in that this type of fishery almost inevitably leads to extreme overexploitation of a few species. A typical pattern for multispecies fisheries that use non-selective gears to exploit assemblages where all species are landed and have market value is to progressively remove the larger, less resilient species in the system (Jennings *et al.* 1999). Thus, the species composition of the system and the catch is shifted towards the smaller, usually less valuable, more resilient species. However, even though the less resilient species may be reduced to low population sizes, they continue to be exposed to the high levels of fishing effort. Coral reef fisheries provide the classical example of this pattern (Koslow, *et al.* 1988). In these the large snappers and groupers are quickly removed from the system but, owing to their high value, even at very low abundance, these species continue to be traded when caught. The likely result of a trade ban in this situation would be that these species would be retained for domestic sale or personal consumption. However, in certain circumstances there could be an increase in discarding the fishes, in which case the survival of discarded species is a critical issue.

Therefore, the efficacy of trade restrictions in reducing the risk of extinction due to fishery exploitation will be highest for traded target species. These restrictions will result in the least social and economic disruption when the fishery is monospecific. Restrictions on trade of non-target species will be effective only when they are discarded and survive. In these fisheries, there is the need for a focus on the use of more selective gears or fishing strategies, so that the catch of non-target species is minimized. This is an issue of concern to fisheries managers, because the use of more species-specific gears and strategies facilitates the optimization of yield on a species by species basis.

2.5 Review of the literature on species extinctions and risk

On geological time scales, many fish and invertebrate species have disappeared naturally from aquatic habitats, as many species have been lost from all types of ecosystems. However, present extinction rates of aquatic species are conjectured to be much higher than background rates of extinction (Cairns and Lackey 1992, Malakoff 1997, Roberts and Hawkins 1999). Because aquatic extinction rates appear to be elevated beyond the historic background rates, conservation concerns demand an inquiry of their causes and consequences. They pose several questions.

- How many fish and invertebrate species have actually gone extinct in geologically recent times?

- What characteristics did they share, and what caused their losses?
- What conservation measures would help to reverse the declining trend in aquatic biodiversity?

Answers to those questions help to clarify the appropriate role for trade-related agencies in implementing measures for the conservation of species at risk of extinction.

In this section, the literature on frequency and patterns of extinction in aquatic species are reviewed to address the above questions and to determine if they indicate that risk of extinction can be predicted from ecological attributes of the species and the characteristics of their habitats, as suggested in the previous section and by several authors (e.g. McKinney 1997, McDowall 1999). The extent to which this appears possible will determine the feasibility of pursuing a quantitative approach to prediction, such as has already been explored by Angermeier (1995) and Parent and Schrimi (1995) for the fishes of Virginia and the Laurentian Great Lakes region.

Before undertaking the review, it is important to provide several warnings. As many authors have stressed (e.g. Reaka-Kudla 1997, Roberts and Hawkins 1999) analyzing patterns in documented extinctions may be misleading, because documented extinctions may underestimate actual number of extinctions for several reasons. Scientifically, documenting the extinction of a species is proving something does not exist any more, which is logically, practically, and philosophically more difficult that proving the existence of something (Diamond 1987, Miller *et al*. 1989). Hence, it is possible that some species assigned to a category of high risk may already be extinct, but careful scientists are still conceding the possibility that future sampling may yet discover remnant populations. The precautionary approach would suggest that when the present existence of a species is in doubt, the burden of proof should rest with those arguing that the species is *not* extinct. However, the precautionary approach does not ensure that all extinctions which have occurred have been reported in the scientific literature. On the other hand, a few fish species considered to be extinct, sometimes for long periods, have been rediscovered either by accident (*Latimeria chalumnae*, Bruton 1995b) or as a result of diligent searching (*Cyprinodon radiosus*, Miller and Pister 1971, *C. nevadensis shoshone*, Taylor *et al*. 1988). The challenge of estimating true extinction rates for aquatic organisms is complicated further because the fish and aquatic invertebrate faunas of many parts of the worlds are poorly sampled, particularly in the oceans (Upton 1992, Bruton 1995, Moyle and Leidy 1998). Moreover, the taxonomies of some groups, particularly marine invertebrates, also are only poorly resolved, and in some species groups, individual species are difficult to resolve, especially based solely on morphological criteria applicable to historic collections (Reaka-Kudla 1997, Roberts and Hawkins 1999). Therefore the possibility of "crypto-extinctions" – species lost without ever having been known to exist - must be considered seriously.

However, such consideration can contribute little to scientific dialogue, as there are no facts with which to work. Even model-based estimates of crypto-extinctions of terrestrial organisms, where uncertainty of taxonomy and inadequacy of sampling are both less severe than in aquatic habitats, commonly vary by an order of magnitude, for example from 100 to 1,000 species of insects per year (Burgman *et al* 1993). Fortunately, from the perspectives of fisheries management and trade regulation, crypto-extinctions of targeted commercial species would not be a major concern, because in almost all cases managed commercial harvests and trade will be with either food products or aquarium products, whose species identities are known. Any concerns regarding crypto-extinctions as a result of fisheries would most likely arise in, for example, small-scale fisheries targeting high diversity assemblages, or for species such as rare

benthic invertebrates killed by fisheries operations or the habitat of which is destroyed through such operations. The risk is also likely to be higher when the species are no longer recognizable in the final fishery product, e.g. whale oil or fishmeal from high-diversity demersal stocks (fortunately extremely rare!).

In marine ecosystems there are very few documented cases of recent species extinctions of fishes and invertebrates, although a number of marine mammals and birds have been lost (Baillie and Groombridge 1996, Ruckleshaus and Hays 1998, Roberts and Hawkins 1999). The eelgrass limpet of the northwest Atlantic nearshore (*Lottia alveus*) is accepted as extinct (Carlton *et al* 1991) and two (Roberts and Hawkins 1999) or three (Carlton 1993) other invertebrates (a limpet; *Collisella edmitchelli*, and a periwinkle *Littoraria flammea;* both rare and known from a few museum collections; and a snail *Certhidea fuscata*) are listed as probably extinct. None of those species were harvested commercially, or suffered significant mortality as bycatch; and hence were not impacted directly by trade. The eelgrass limpet population collapsed when its obligatory habitat, coastal eelgrasses, was decimated by disease, and although the habitats have recovered in some coastal areas, the limpet has never been found in recent decades. Both *C. edmitchelli* and *C. fuscata* had restricted coastal distributions in the nearshore and intertidal zones of southern California. Habitat loss attributed to urbanization and human activities in the coastal zone has been presented as the cause of loss of both species (Carlton 1993, Taylor 1991), the former probably lost in the previous century; trade in the extinct species or their parts never occurred.

Freshwater species have been lost at much greater rates. For the United States, where fish faunas have been relatively thoroughly monitored, Bruton (1995a) lists 18 freshwater species as extinct or "almost certainly" extinct, and a global total of 34 species. This total is certainly low, as almost all the 80 species of fish listed in the 1996 IUCN Red List are freshwater species. In Lake Victoria alone, some experts have estimated that as many as 200 endemic haplochromines from the original species flock of 300 or more species may now be extinct, and attributed the extinctions to the effects of first overfishing, and then the introduction of Nile perch (*Lates niloticus*) and Nile tilapia (*Oreochromis niloticus*), (Witte *et al*. 1992, Ogutu-Ohwayo *et al*. 1997). Other great African lakes have been argued to have suffered similar proportionate losses in numbers of species, although from somewhat smaller species flocks (Ogutu-Ohwayo *et al*. 1997). For these endemic species groups, over-harvesting was a major contributor to large declines in abundance. However, the change from greatly reduced abundance to extinct is attributed to impacts of the introduced predator and possibly the tilapia competitor.

A similar sequence of causal factors has been invoked for the extinction of several coregonids (*Coregonis alpenae, C. johannae, C. kiyi orientalis,* and *C. negripennis*) and blue pike (*Stizostedion vitreum*) from the North American Great Lakes (Miller *et al*. 1989), although in the case of the North American Great Lakes it was caused by the parasitic sea lamprey (*Petromyzon marinus*) which invaded the lakes, rather than a predator. Interbreeding with other ciscos is also invoked as a contributing factor in the extinctions of the coregonids. Like the situation in the African great lakes, however, intensive overfishing for an extended period greatly depleted the populations, before the additional factors resulted in extinction.

This sequence of over-exploitation followed by species introductions is not the only route to extinction, however, nor possibly even the most common. Of the 40 species and subspecies listed as extinct in Canada, Mexico, and the United States in Miller *et al* (1989), 29 had restricted distribution, usually occurring in only a single small lake or watershed. In their summary, Miller

et al (1989) cited physical habitat alteration in 73% of extinctions and chemical habitat alteration and hybridization were each invoked in 38% of the cases. By contrast they reported introduced species effects in 68% of the extinctions, and overharvesting in 15%. Although a few species of salmonids (*Oncorhynchus* and *Salvalinus*) and suckers (*Chasmistes*) were harvested recreationally or even commercially, directed fishing or bycatch mortality played no role in the extinction of the large majority of the 29 species which were originally of restricted distribution.

More recent reviews of characteristics of aquatic species which have been lost to extinction, the causes of extinction, and the types of habitats which they occupy, have tended not to separate species which are extinct from those at risk of extinction, or extirpated from portions of their earlier ranges (ex. Leidy and Moyle 1998, Ruckleshaus and Hays 1998, McDowall 1999). However, analyses later in this Section address these patterns for the more up to date lists of extinctions of fish.

This concern for extirpations of populations of species is consistent with the importance of conservation of aquatic biodiversity on local and regional as well global scales (Cairns & Lackey 1992). Inventories of reduced aquatic biodiversity at the level of watersheds or regions show consistent patterns of substantial losses (ex. Hughes and Noss 1992, Moyle and Leidy 1992). Experts generally have invoked physical alteration of the habitat, fragmentation of suitable watersheds, and cascading simplification of communities (where the loss of one species may trigger further changes in the viability of species which were predators on or prey for the species which originally was lost) as causes of the loss of biodiversity. Interpreting these patterns, however, is complicated by the very spotty knowledge of biodiversity of many geographic regions and taxonomic groups (Leidy and Moyle 1998, Roberts and Hawkins 1999).

Acknowledging that the details of any view of aquatic biodiversity based on information presently available is unlikely to be representative of the true global status of aquatic biodiversity, some patterns are nonetheless clear. Anadromous and estuarine species seem particularly vulnerable to local and regional losses (Jonsson *et al*. 1999, McDowall 1999). Probably the group of species most thoroughly studied at the finer scale of populations of species is salmonids in the Pacific Northwest of North America. Extirpations of populations or stocks of anadromous salmonid species have been inventoried in Nehlsen *et al*. (1991), Slaney *et al*. (1996), and Baker *et al*. (1996).

It was conjectured that at least 106 Pacific salmon stocks had been extirpated in the continental US (Nehlsen *et al* 1991), although unfortunately the total number of stocks reviewed is not clear in that report. In adjacent Canadian watersheds to the north, Slaney *et al*. (1996) reported that of 5,487 stocks for which data were sufficient to estimate status, as many as 142 stocks may have been extirpated. In Alaska watersheds, however, only two stocks had been extirpated, from a total of over 4,000 stocks for which there were sufficient data to evaluate current status.

This decrease in rate of extirpation parallels a decrease in density and the impacts of humans. In all three reviews of Pacific North American salmonid stocks, the main causes of past population reduction and extirpation were all associated with human activities. Many of the extirpations were attributed to degradation of freshwater habitats or complete destruction of streams from urbanization or blockages due to hydroelectric development. Reductions in habitat quality were also associated with land use practices, water quality and water removal problems, and mortality associated with passage of smolts or returning adults through dams.

Despite the focus on habitat loss and degradation in all three detailed evaluations of losses of salmonid stocks, the three teams of authors acknowledged that excessive exploitation may have played some role in at least reducing populations to low abundance, if not all the way to extirpation. In all cases it was reported that the least productive stocks could have suffered unsustainably high mortality in fisheries at sea or near shore, where salmon of many different stocks mixed together, even if the exploitation rate on the mixed stock complex was appropriate for the average productivity of the complex. Moreover, more recently noteworthy declines of some complexes of salmonids, such as coho salmon in rivers in the interior of British Columbia, Canada, have occurred in regions where freshwater habitat quality has not been degraded significantly. In these cases, the declines (which may include some local extirpations) are conjectured to be caused largely by decreasing marine survival rates, resulting in turn from changing ocean conditions and over-harvesting in mixed stock fisheries (Bradford 1995, 1998).

Population structure of most other species is known more poorly than that of salmonids. Nonetheless, progressive loss of biodiversity through regional extirpations is of concern in many areas (Angermeier 1995, Leidy and Moyle 1998, Ruckleshaus and Hays 1998). Many species of sturgeons also have undergone substantial reductions in range, and several are extirpated from many watersheds where they once occurred (Musick 1998, Baillie and Groombridge 1996).

At the population scale, biodiversity losses are readily apparent. Bruton (1995b) summarizes that 122 of the 200 native species of Europe were listed in the Berne Convention as needing special protection and thousands of individual populations have become extirpated. In Australia, 65 species (34%) are considered at some level of risk and several species are on the verge of extinction. Data for Asia and Africa were even more incomplete, but in South Africa 32 species were listed as being at risk. In Nepal, 13 of 130 native species were assigned by scientific authorities to some category of risk, and in Japan, 45 species were categorized as at risk. Taxonomic groups with coastal and estuarine distributions such as abalones (*Haliotis)*, seahorses and pipefish (Family Syngnathidae), and groupers (Family Serranidae) are frequently represented on lists of species at risk or populations extirpated over large parts of their historic ranges (Baillie and Groombridge 1996, Powles *et al* in press). On continental shelves, documentation of regional extirpations perhaps is best for once widespread sharks, skates and rays, such as common skate (*Raja batis*) in the Irish Sea (Brander 1981) and barndoor skate (*Raja laevis*) on the Grand Banks of Newfoundland (Casey and Myers 1998).

Such inventories of species lost to extinction, extirpated over large parts of historic ranges, or at risk of extinction, convey clearly the need for conservation measures to protect biodiversity on many scales. Further analyses are needed to clarify what sorts of measures might be most constructive, however. Such analyses are undertaken (including in this document), but can begin with only very coarse information on life-history traits, range information, and fishing histories of species of interest. Nor, as noted in the above, are the species of concern likely to be representative samples of the marine, estuarine, anadromous, or freshwater fish communities. Ample opportunity exists to carry the following analyses much further. Nonetheless, even the inital analyses below shed some light on the types of species of greatest concern and help clarify the role of commercial exploitation as a threat to species at current or potential risk.

The preceding literature review indicates most authors have concluded that risk of extinction of aquatic species is closely linked to their ecological attributes, the characteristics of their habitats, and through these to their vulnerability to anthropogenic factors. Two additional

perspectives on the species that are perceived to be at greatest risk are provided below by reviewing two sets of information:

- the species included in the 'Threatened fishes of the world' series in the journal Environmental Biology of Fishes, introduced by Bruton (1995b);
- the fish species listed by IUCN in seven categories of state (see Annex 1 of this document), (Baillie and Groombridge 1996).

The 'Threatened fishes of the world' articles are provided voluntarily by authors as a means of drawing attention to the species. They are thus a reflection of concern by experts, rather than an attempt to provide a comprehensive picture. The summary in Table 1 shows that of the 63 species in the series most inhabit freshwaters, and most are small species. The two large marine species are the coelacanth and the great white shark.

Table 1. A summary of the characteristics of the fish species included in the 'threatened fishes' series from the journal Environmental Biology of Fishes

Size category	**Marine**	**Brackish**	**Anadromous**	**Freshwater**	**Total**
Large (>30 cm)	2		3	2	7
Medium (10-30 cm)	1			13	14
Small (<10 cm)	1	6		35	42
Total	4	6	3	50	63

A summary of the information on fishes provided in the 1996 IUCN Red List (Baillie and Groombridge 1996) is shown in Annex 1 of this document. Information on size is not provided but can in many cases be inferred roughly from knowledge of the family or genus. Use of the 1996 IUCN categorizations does not imply acceptance, by the authors of this report, of the absolute evaluation of risk in each case, as the basis for many of these are currently under review (Workshop reports from London and Tokyo). However, the tabulation of the conclusions of the IUCN does permit investigation of ecological patterns among species judged to be at risk by that organization.

With regard to extinction and extinction in the wild, the list includes 91 freshwater and 2 marine species. The freshwater species are from 12 families, predominantly the cichlids (49 spp.), cyprinids (16 spp.) and cyprinodontids (9 spp.). Significantly both marine species on the list are sturgeons.

Similarly for species in the three categories of endangerment[2] there is a preponderance of freshwater fishes (620 freshwater species versus 138 marine). Within these categories, the proportion of critically endangered species is relatively higher in the case of freshwater fishes (24% for freshwater species versus 10% for marine). Cyprinids (161 spp.) and cichlids (88 spp.) are again the most prominent freshwater families, followed by the cyprinodontids (31 spp.) and percids (33 spp.). The latter family consists primarily of etheostomatine darter species (27 spp.) that are small with specialised life-histories and restricted distribution in small streams. The cyprinodontids also have specialised life-histories and occupy restricted habitats such as desert

[2] CR = Critically endangered; EN = Endangered; and VU = Vulnerable

pool systems. The case of the cichlids of the African Great Lakes has been reviewed above. Twenty salmonid species are listed in these three categories.

Among endangered marine species, the syngnathids predominate (36 spp. all in the vulnerable category), followed by the sturgeons (23 spp., 16 in the endangered category), and the serranids (17 spp. 13 in the vulnerable category). Apart from the special case of the sturgeons, the majority of listed marine species that are subject to exploitation are taken in small-scale tropical and artisanal fisheries for food (serranids, lutjanids, labrids) and the live food and aquarium trades (many families; see also Sadovy 1997). The largest group, the syngnathids (34 of them seahorses), are also in high demand for their supposed medicinal properties (e.g. Pajaro and Vincent 1996).

Few listed species support large-scale commercial fishing. Those that are include swordfish, four species of tuna (Atlantic bigeye tuna, northern and southern bluefin tuna, and albacore tuna) two gadids (Atlantic cod and haddock) and two flatfishes (Atlantic halibut and yellowtail flounder), and even in reduced states these have populations well above any risk of imminent extinction. For North Atlantic albacore, the 1997 estimate of spawning stock biomass is about 20,000 metric tons. For Atlantic bigeye tuna the 1997 spawning stock biomass is about 150,000 metric tons. For west Atlantic bluefin tuna, the number of mature individuals was estimated at about 30,000 (ICCAT 1999). Whereas, these numbers indicate that fisheries management has failed to conserve these stocks at acceptable levels, they do not indicate that the stocks are at imminent risk of extinction.

2.6 Assessing risk of extinction of aquatic species

The literature and the two perspectives provided by the ‘Threatened fishes’ series and the IUCN Red List indicate that the distribution of species observed or considered to be at risk is highly aggregated among the global population of fish species, and that this aggregation is closely linked to ecological attributes and habitat characteristics. These patterns help clarify what types of species are likely to be at risk of extinction, and that knowledge, in turn, can help clarify where measures such as restrictions on trade, may contribute most to reducing risk.

Before attempting to summarize these characteristics, it must be stated that aggregations of listed species also appear to reflect the distribution of concern of conservationists and even more so the distribution of technical capacity for assessing risk of extinction. For example, there is a relatively high number of listing for the well studied freshwater fish fauna of North America, and a relative low number of the fish faunas of tropical freshwaters in India, Asia, South America and (with the exception of the lacustrine cichlids) Africa. However, the aggregations of listed species also coincide with those regions that have experienced most development and possibly most habitat modification and destruction.

The review of information on extinctions and species at risk of extinction indicates that there is a variety of factors that can be used as indicators of risk. The following generalisations appear to be reasonable:

a) large, long-lived, late-maturing species, with both high and low fecundity, but more so the latter, that are vulnerable to exploitation are at relatively high risk of extinction from exploitation;

b) small, short-lived species that have restricted distribution in isolated habitats are at relatively high risk of extinction from non-exploitative human action such as habitat destruction and degradation or localised catastrophic events (e.g. oil spills);

c) small, short-lived species that have reproductive specialisation resulting in low intrinsic rate of population increase and that have restricted distribution in isolated habitats are at relatively high risk of extinction from exploitation as well as non-exploitative human action;

d) species in freshwater habitats are more likely than those in marine habitats to be at risk from habitat destruction and degradation;

e) proximity to large human populations tends to place species at greater risk, or make it more likely that risks will be identified and reported in the literature.

Another issue relating to assessment of risk in aquatic species is the availability of information. This will affect both whether or not a species can be considered for listing, and if it can, what attributes will be evaluated. The IUCN Red List of 1996 includes enough fish species to permit analyses which are instructive in the regard. Table 2 summarises the use of each of the IUCN listing criteria for marine and freshwater fishes in their three categories of endangerment (CR = Critically endangered; EN = Endangered; and VU = Vulnerable).

Table 2 indicates that the decline criterion (A) is much more frequently used for marine fishes than for freshwater ones. This probably reflects the fact that there is generally more information on the distribution and abundance of freshwater species than on marine species, so status relative to abundance and distribution can be evaluated more often.

The factors listed can be used in an heuristic fashion to identify the species which may be at highest risk of extinction, so that conservation can focus on the needs of these species. This is undoubtedly the way that most conservationists are presently approaching this issue.

Alternatively, the information on these factors could be used to develop a quantitative multivariate predictive model that would identify the species or clusters of species that would be at highest risk of extinction, as was undertaken at regional scales by Angermeier (1995) and Parent and Schrimi (1995). Projects of this nature, but on oceanic and global scales, are underway with some international conservation organizations. The goal of all these analyses is to group species into clusters with similar sets of characteristics, and specify how the risk of extinction would vary among clusters, and according to the characteristics which defined the clusters. Such a system would be useful both to set priorities among species for evaluation of status, and to suggest types of conservation measures most appropriate for the particular threats likely to be faced by different species. Population Viability Analysis (Box 1), a basic analytical tool of conservation biology, also could be used at the level of the cluster. The purpose would be to identify appropriate numerical guidelines for evaluating risk to different types of species, and to achieve some constant degree of protection against extinction across the diversity of fishes and aquatic invertebrates.

Table 2. Summary of criteria used in listing marine and non-marine fish species in the endangered categories

Why listed (1)	Number of species in category			Total	Percent of total
	CR	EN	VU		
	Not marine				
A	41	30	81	152	24.5
AB	53	39	27	119	19.2
ABC	6	2	1	9	1.5
ABCD			3	3	0.5
ABD			7	7	1.1
AC	5	3		8	1.3
ACD			1	1	0.2
AD	2		11	13	2.1
ADCD			1	1	0.2
AE		1		1	0.2
B	35	34	19	88	14.2
BC	1	4	0	5	0.8
BD			8	8	1.3
BE	2			2	0.3
C	3	3	2	8	1.3
CD			2	2	0.3
D		1	192	193	31.1
	148	117	355	620	
	Marine				
A	27	62		89	65.4
AB		3		3	2.2
AD		1		1	0.7
B	1	1		2	1.5
C	1			1	0.7
D		28		28	20.6
NT			12	12	8.8
TOTAL	29	95	12	136	

(1) A = Declining population (past or projected); B = Small distribution and decline or fluctuation; C = Small population size and decline; D = Very small population and very restricted distribution; E = Quantitative analysis (e.g. Population Viability Analysis); NT = near threatened

2.7 Summarising contrasts between fishes and aquatic invertebrates and terrestrial vertebrates

Almost all the life-history strategies found in terrestrial vertebrates can be found in fish and aquatic invertebrates, and adding marine mammals and seabirds to the list of aquatic species increases the overlap further. However, the reverse is not true, as a wide range of adult sizes, more complex life-history patterns, with ecologically distinct larvae, juveniles, and adults; diadromous life styles, and many other specialized features of life-history strategies are present in the diversity of species of fish and aquatic invertebrates. The diversity of life-history strategies of fish and aquatic invertebrates alone means that criteria of evaluating risk of extinction which are robust to the diversity of terrestrial vertebrates are not assured to provide comparably robust evaluations of risk of extinction of all aquatic organisms. Moreover, differences can work in both

directions, as complex life-histories can make species more resilient to certain types of threats to their survival and more vulnerable to other types of threats.

BOX 1: POPULATION VIABILITY ANALYSIS

Population viability analysis (PVA) is a term applied to a range of population analysis modelling approaches, which have in common that stochastic population trajectories are projected into the future, based on present knowledge of mortality and fecundity schedules, and scenarios about possible future conditions (Groom and Pascal 1998). Many, but not all, are based on Leslie or Lefkowitz matrix approaches to projections of age- or life-history structured populations. Outputs are generally expressed as either the risk that a population falls to zero (or some arbitrarily small value at which recovery is considered unlikely) within a specified time interval, or the distribution of time intervals before the family of population projections falls to zero or the threshold of no recovery. Either set of outputs can be readily interpreted in the context of risk of extinction of the population being modeled.

Current methods almost always incorporate uncertainty in many factors, including uncertainty about population processes and parameter values and stochasticity in future environmental conditions. Details of how uncertainty is addressed in PVA vary widely among individual applications, and no single treatment is emerging as universally recommended, or even strongly preferred (Burgman *et al* 1993, Groom and Pascal 1998). Nonetheless, it is often choices among alternative formulations of population processes, such as density dependence of population growth rates or depensation of reproduction at low abundance (often referred to as the "the Allee Effect") (Courchamp *et al* 1999, Stephens and Sutherland 1999), or assumptions about the magnitude of interannual correlations of environmental stresses (Gilpin 1990, Ferson and Burgman 1995), which have the largest effects on PVA results.

As explained cogently by Caughley (1994), the strength of PVA is in projecting the possible fates of populations which are small enough that either or both of environmental and demographic stochasticity may affect the likelihood that a population can persist for a time interval of decades to centuries. Once a population has become small, many theoretical developments in quantitative population genetics contribute importantly to estimating risk of extinction due to demographic factors such as inbreeding depression, stochastic imbalances in sex ratios, etc. Theory is less helpful in dealing with vulnerability to environmental catastrophes, where there is little substitute for knowledge of how specific environments vary (Tuljapurkar 1990, Caughley 1994). Likewise, the degree to which reproductive potential is decreased when a population is small, and what constitutes "small" for particular types of species has great impacts on the estimated viability of populations, yet depensation parameters of stock - recruit relationships (i.e. how much, if at all, per capita reproductive output falls when abundance is very low) are generally among the hardest parameters to estimate for most species (Burgman *et al* 1993), and even when data allow their estimation, they have particularly high uncertainty (Liermann and Hilborn 1997).

Fish and aquatic invertebrates also show greater maximum fecundities and greater diversity in strategies for dispersal of reproductive products than do terrestrial vertebrates. These traits make both the implications of population fragmentation and the potential for recovery from depleted abundance much more variable among aquatic organisms. These considerations also mean criteria sufficiently robust to be suitable for all terrestrial vertebrates may not provide suitable evaluations for all aquatic species. Greater potential fecundity and dispersion would tend to make aquatic species more resilient to depletion and result in a lower risk of extinction, whereas at low densities of spawners or recruits, reproductive depensation (the "Allee effect" referred to above) may place aquatic species at greater risk. (We note that plants, like aquatic organisms, have a wide range of life-histories and reproductive potentials, compared to terrestrial vertebrates, and it is likely that one set of criteria for evaluating risk of extinction of all plant species does not give equally robust evaluations of risk for every plant species)

Exploitation of fish and aquatic invertebrates is also highly variable in contrast to exploitation of terrestrial vertebrates. Fisheries can be highly mechanised, and collect large numbers of highly aggregated fish with a single haul. Mixed species fish harvests may also allow fishing mortality to be maintained (as by-catch mortality) on species which have become quite rare, even when the species is of little or no commercial value. In contrast, terrestrial vertebrates tend to be harvested singly or at least in much smaller numbers per shot or per trap but can also more easily be detected, even at very low levels of abundance.

Reviewing the literature on extinctions and species currently judged to be at risk indicates that threats to habitat pose the greatest threats to both terrestrial and aquatic organisms. The association between risk of extinction and damage to habitats is particularly strong for aquatic species in freshwater and coastal zone habitats, and in enclosed seas. Aside from a few species of marine mammals and seabirds which were highly vulnerable to uncontrolled harvesting, essentially all extinctions or large scale extirpations of aquatic organisms have been associated with substantial alterations or degradation of their habitats.

3 THE CONTEXT OF CITES IN MARINE CONSERVATION SYSTEMS

3.1 Institutional arrangements to promote marine conservation

Because CITES is designed to assist with the conservation of species at risk of extinction, it is a conservation tool of last resort. Thus, in assessing the implications of the revised CITES criteria for aquatic organisms in general, and marine fisheries in particular, it is vital to first consider all the mechanisms available to facilitate marine environmental and living resource conservation. The bedrock of these is national legislation that countries enact for the proper conservation of resources in their own inland waters, territorial waters and in their exclusive economic zones (EEZs). However, many marine and diadromous resources and some fresh water resources have ranges that span the waters of a number of countries and some resources partly or wholly inhabit international waters. Consequently, their harvest is shared. Moreover, the waters of the seas and some inland waters are shared and problems resulting from contamination, pollution, eutrophication, introduced species etc. are often shared problems. Hence, in addition to national legislation, there are numerous international organizations and instruments whose purpose is to achieve conservation of marine and other aquatic resources. Some of these are legally binding upon countries, while others are only agreed in principle, and are dependent on the will and capacity of national Governments to give them force.

For marine fisheries, international action is based on the United Nations Convention on the Law of the Sea (UNCLOS, United Nations (1983)). In addition there exist a wide range of more specific international conventions, agreements and arrangements for marine conservation (see Annex 2 of FAO 1996a). All international instruments related to fisheries (including the UNCED Agenda 21) recognise the important role to be played by the regional fishery management organizations in the rationalization of fisheries, particularly in the high seas, for straddling stocks and highly migratory species.

Most of the numerous international bodies with responsibility for marine conservation and management have been in place for several decades. Of the bodies with direct responsibility for fisheries, the International Whaling Commission (IWC) is global. Most others are regional and sub-regional, for example: the International Commission for Conservation of Atlantic Tunas

(ICCAT); the North Atlantic Fisheries Organization (NAFO); the Indian Ocean Tuna Commission (IOTC); and the Inter-American Tropical Tuna Commission (IATTC).

Several other organisations have a mandate for marine environmental management and pollution control. Some examples are: the Oslo and Paris Commission on Marine Pollution (OSPAR); regional conventions and agreements developed under the UNEP Regional Seas Programme; and elements of the UNESCO Intergovernmental Oceanographic Commission's regional sub-bodies.

Through the late 1980s and early 1990s, it became evident that many of the world's most important fishery resources were fully exploited, a number heavily overexploited and some collapsed. This was widely acknowledged and became a focal issue for international fisheries management. In 1991, the FAO Committee on Fisheries called for new concepts that would lead to responsible sustainable fishing. The International Conference on Responsible Fishing in 1992, asked FAO to prepare a Code of Conduct to address these issues.

The 1992 United Nations Conference on Sustainable Development (UNCED) added impetus to marine resource and environmental conservation through its Agenda 21, Chapter 17 on the oceans (United Nations 1992), and through adoption of the precautionary principle. These issues were pursued further as they relate to small island developing states (SIDS) at the Global Conference for Sustainable Development of SIDS in Barbados 1994.

The FAO Code of Conduct for Responsible Fisheries (FAO 1995) was developed over several years to address growing global concern for the impact of fisheries on exploited living aquatic resources and their ecosystems. It prescribes basic conservation principles and objectives for sustainable use of exploited populations and ecosystems - it provides guidelines for achieving those objectives in each of its six areas of concern and for the application of the precautionary approach (FAO 1996b).

The Code of Conduct is an international agreement that is not legally binding, although many countries are in the process of incorporating it into national policy and legislation. The Rome Declaration on the Implementation of the Code of Conduct for Responsible Fisheries adopted by the FAO Ministerial Meeting on Fisheries, March 1999, acknowledged the importance of the Code of Conduct and asked FAO to urgently pursue its implementation. In the Declaration, states also committed to collaboration with other countries, and inter-governmental and non-governmental organizations in implementing the Code of Conduct.

The UN Fish Stocks Agreement is a global, internationally binding instrument that prescribes the responsibility of states that participate in exploitation to cooperate in management of the transboundary resources (United Nations 1995). It elaborates on the provision of the Law of the Sea for management of straddling and highly migratory stocks. Under it, states should collaborate in management through existing bodies or where none exist establish them.

Progress with the implementation of Agenda 21, Chapter 17, the SIDS Program of action and the various fisheries and marine conservation instruments are reviewed and reported on regularly by the UN Sustainable Development Commission.

BOX 2: CONVENTION ON BIOLOGICAL DIVERSITY

Article 1of the Convention states the objectives of the convention as " […] the conservation of biological diversity, the sustainable use of its components and the fair and equitable sharing of the benefits […]."

Other articles address the need to conserve ecosystems, to address problems at the national and internationals levels, and collaborate with national and international agencies as appropriate.

With regard to sustainable utilisation, the convention states that these considerations should be integrated into national decision-making.

The global perspective on fisheries described above, coupled with international environmental conservation instruments such as the Convention on Biodiversity, 1992 (Box 2), provides an expanded mandate for national fisheries administrations and for established and new fisheries management and conservation bodies. To be consistent with the range of international instruments and agreements that pertain to environmental conservation, there is the need for fisheries organizations to incorporate these concepts into fisheries management planning and control. This is being actively pursued in many countries as part of biodiversity action plans and the development of ecosystems management systems (for example the UK Biodiversity Action Plan, the EU Habitats Directive, US modifications, in 1996, to the Magnuson-Stevens Fishery Conservation and Management Act). It is also taking place at the international level within existing frameworks, such as ICES which has established working groups that address the impacts of fisheries on marine ecosystems and approaches to ecosystem level management. In the seas around Antarctica, CCAMLR was established explicitly to approach exploitation and conservation at the ecosystem level (Box 3).

Despite clear mandates to ensure fisheries are sustainable and living resources are conserved, many fisheries management agencies have failed to achieve conservation of all resources under their jurisdiction (Garcia and Newton 1997). Clearly, the response to the past failures of fisheries management to conserve exploited resources adequately and the heightened awareness of the impacts of exploitation on ecosystems has resulted in an enhanced set of instruments and institutions for sustainable use of these ecosystems. As this new direction is developed and tested, there will be problems to be solved and undesirable circumstances against which there will be the need to provide safeguards.

BOX 3: CONVENTION OF THE COMMISSION FOR THE CONSERVATION OF ANTARCTIC MARINE LIVING RESOURCES (CCAMLR)

The objective of CCAMLR is the conservation of Antarctic marine living resources with conservation defined to include rational use. The conservation set down in the Convention requires that:

(i) exploited populations must not be allowed to fall below a level close to that which ensures their greatest net annual increase;

(ii) depleted populations must be restored to such levels;

(iii) ecological relationships between harvested, dependent and related species be maintained; and

(iv) risks of changes to the marine ecosystem that are not potentially reversible within two or three decades must be minimised.

These stringent principles embody what has been called the ecosystem approach to living resource conservation and set the Convention apart from other marine management regimes. Management of fishing must not only conserve the targeted species but take into account the impact of fishing on animals that prey on and compete with the targeted species. In its interpretation, the Convention requires that management action should take account of the impact of activities on all living organisms in the Antarctic or subsystems.

The area of application of the Convention was to approximate, as closely as possible, the Antarctic Convergence, an oceanographic boundary formed where the circulation of cold waters of the Antarctic ocean meets the warmer waters to the north. The Convergence is an effective biological barrier: very few species migrate across it. It is thus a natural boundary within which to manage the resources of the Antarctic.

It was realized at the establishment of CCAMLR that in order to regulate Antarctic marine living resources in accordance with the 'ecosystem approach' embodied in Article II, the effect of such harvesting on dependent species would have to be monitored. The animals primarily indicated by the phrase 'dependent species' in this context are those which are predators on the harvested species (currently krill and fish), such as birds and seals.

CCAMLR started planning its CCAMLR Ecosystem Monitoring Program (CEMP) with the following aims:

(i) to detect and record significant changes in critical components of the ecosystem, to serve as a basis for the conservation of Antarctic marine living resources; and

(ii) to distinguish between changes due to harvesting of commercial species and due to environmental variability, both physical and biological.

The program's largest component is the monitoring of dependent species (predators), but in order to distinguish between changes due to harvesting and due to environmental variability, the program also monitors harvested species, harvesting strategies and environmental parameters.

3.2 Objectives and techniques of fisheries and ecosystem management

The objectives of fisheries management are best stated as the achievement of a number of sustainable social and economic goals within the constraints set by the biology of the exploited species. Ecosystem management extends these objectives to include the need to maintain a healthy ecosystem as the context for human use. This thus includes the maintenance of biodiversity and environmental functions.

BOX 4: TYPES OF MANAGEMENT REGIMES

Conventional fisheries management: Management regime using conventional measures to ensure sustainable exploitation of the resource by regulating fishing operations through catch and effort controls as well as gear restrictions. Typically it focuses on single or a limited number of important stocks. If effective it succeeds in reaching sustainable social and economic goals within the constraints set by the biology of those exploited species identified as being most important. In this report, the term functional fisheries management refers to a management regime that has proven to be effective in realising its sustainability targets.

Precautionary management: In line with the precautionary approach, a management regime taking into account the inherent uncertainty of the resources and fishery system to minimise probability of negative outcomes. As uncertainty and risk are integral parts of fisheries management at any stage of development of a fishery, precautionary management practices should not be seen as measures for unusual circumstances only, but should be an integral part of "good management practice" in all forms of fisheries and ecosystem management as recommended in the FAO Code of Conduct for Responsible fisheries and related guidelines. Nevertheless, precaution should increase as stocks decline.

Ecosystem management: An extension of conventional fisheries management which includes conventional fisheries management and focuses on maintaining a healthy ecosystem as the context for sustainable exploitation of a resource. It takes special account of: the need to maintain biodiversity; to manage for dependent and associated species as well as target species; maintain/rehabilitate habitat; and takes account of natural environmental fluctuations and degradation. In this report, the term functional ecosystem management refers to an ecosystem management regime that has proven to be effective in realising its sustainability targets.

Fisheries Management: **Beyond Limit Reference Points**: A special management regime, requiring extraordinary management measures when the resource has been driven below limit reference points, as a consequence of, for example, bad environmental conditions, excessive fishing mortality or both. In effective fisheries management, the probabilities of such events are assessed and their occurrence anticipated. When they do occur, appropriate and extraordinary management measures and systems designed for such eventualities are implemented. However, in many cases extraordinary measures are put in place too late, when the fishery has already become uneconomic (economic "extinction") .

Over time, fisheries science has developed a number of biological and other reference points to assist with achieving management objectives. These have been almost exclusively set for single species targeted by commercial fisheries. In practice, almost all biological reference points have been defined as biological constraints (or limit reference points, LRPs), indicating the limit beyond which the state of the stock and /or fishery is considered undesirable. Expressed usually in terms of spawning biomass, or number of recruits produced per spawner, they could also be set for many other properties (indicators) of stocks, such as their age composition or egg production. As discussed in the next section, they could also be set for social and economic factors, such as income per fishing unit, or catch per fishing unit. LRPs can also be established in terms of fishing pressure such as e.g. F_{max} or F_{MSY}, i.e. as fishing pressure thresholds beyond which the probability of failure in recruitment, through reductions in spawner biomass, increases to an unacceptable degree. Management should strive to keep the fishery system within the limits set by these reference points. Target reference points (TRPs) are values at which the state of fisheries is considered desirable and management should aim to maintain a stock at that level on average. They correspond to objectives and are set in regions of high productivity and high likelihood of sustainability. Management should strive to keep populations near them. In the case of target and limit reference points, estimation of both the reference points and the annual status

of stocks relative to those points should take full account of all sources of uncertainty about stock status, fishery performance and system dynamics.

The concept of Maximum Sustainable Yield (MSY) enshrined in UNCLOS (see earlier) led to the adoption of MSY as an important, formally and internationally agreed, reference point. Conventionally calculated and used as a measure of a stock maximum potential production, it was *de facto* used for decades (from the 1950s to the 1980s) as an explicit or implicit target reference point for development (i.e. the development objective was to reach this maximum production). Following the recognition, in the 1970s and 1980s, of the limitations of this concept resulting from uncertainty about the true value of MSY and the related effort level, and the relative instability of many resources under such a pressure, the approach to MSY as a TRP has started to change and the present trend (as reflected in the New York Agreement and the FAO Code of Conduct) is to regard it as a limit reference point for development (i.e. a level to avoid reaching) and a minimum standard level of biomass in stock-rebuilding strategies.

More complete reviews of the diversity of potential biological reference points, and the problems in estimating them and implementing management plans based on them, are available in Mace (1994), Caddy and Mahon (1995) and ICES (1998).

Figure 1 shows an illustration of fisheries management and recovery plans on a plot of fishing mortality rate and population size. It also shows the region where CITES provisions might be invoked. It should be noted that functional fisheries management would apply at the stock level while the CITES management would apply at the species level. The figure also indicates that implementation of CITES regulations must be accompanied by appropriate fisheries and ecosystem management measures to ensure success. Since generally CITES regulations would be invoked at very low populations of mature fish, the population is shown on a logarithmic (order of magnitude) scale. Precautionary fisheries management (FAO 1995, FAO 1996a) is appropriate throughout the population range with increased degrees of precaution where the population is reduced. Functional fisheries management and where appropriate ecosystem management should move from those regimes into management beyond limit reference points when the mature population goes below P_{loss} (Figure 1). Management for situations beyond the limit reference points would involve extraordinary measures and should involve a recovery plan aimed at restoring the resources to levels above the LRPs, set on biological grounds, and the fishery to levels inside the LRPs set on social and economic performance. Suitable measures to achieve this could include exceptional effort control and reduction measures, including a moratorium, backed up if necessary by closed areas and/or seasons, and possibly by social and economic measures to re-direct fishing effort and investment and, when appropriate, discourage further exploitation while protecting the coastal community livelihood. However, before this relatively “low” abundance is reached, common interpretations of precautionary management indicate that fishing mortality rate should be progressively reduced as a population or populations approach this level. F_{crash} indicates the fishing mortality rate that, if applied over a long term, is expected to collapse the stock. F_{limit} is the limit reference point for fishing mortality rate set below F_{crash}.

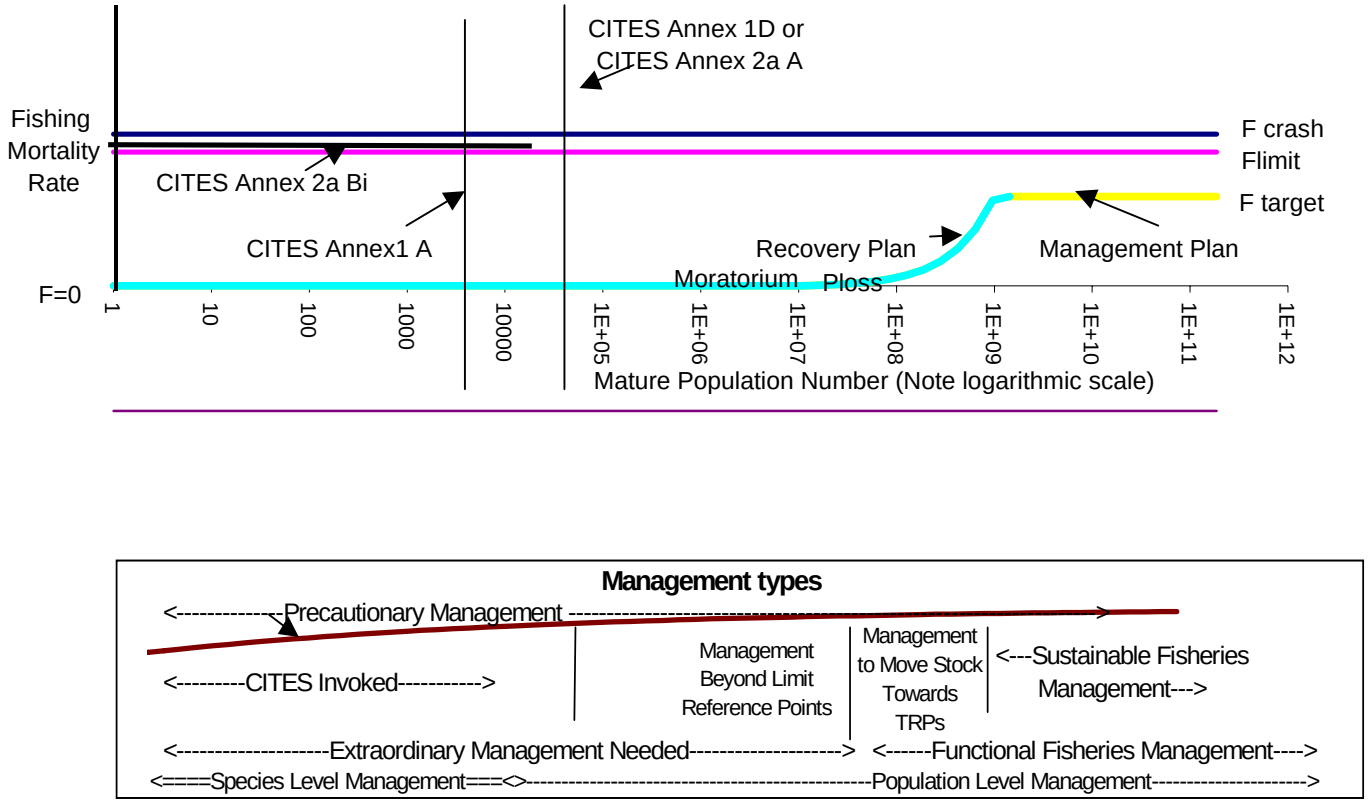

Figure 1. An illustration of various management approaches that might be applied to exploited species such as North Atlantic cod at various levels of abundance, biomass and fishing mortality rate. The actual numbers for the various biological reference points would apply at the stock level and would vary from stock to stock. Those shown on this figure are for illustrative purposes only

As implied by paragraph 7.6.10 of the FAO Code of Conduct (FAO 1995), fisheries management plans should anticipate that the resources and/or the fishery system will, on occasions, fall outside the LRPs, as a consequence of natural factors, errors in or ineffectiveness of the management system or a combination of both. An effective management plan therefore should also include a set of extraordinary measures as discussed above, to be implemented as soon as the stock falls below the LRPS, or is projected to do so in the immediate future. These extraordinary measures should be designed to reduce or eliminate fishing mortality so as to allow the stock to recover to desirable levels. An example of incorporating the steps to be taken when the system is beyond the specified LRPS into a management plan can be found in the South African small pelagics fishery (Cochrane *et al.* 1998). When a total allowable catch is set for South African anchovy, if the stock is above the LRP a minimum TAC is guaranteed, but when the anchovy biomass falls below this LRP, the plan allows for rapid reduction of the TAC, with no guaranteed minimum, depending on how far below the LRP the biomass has fallen. The incorporation of such rules and appropriate measures into a management plan should prevent a

crisis, or at least minimise the probability and extent of a crisis, the response time needed, and the extent of its biological, social and economic consequences.

Fisheries typically operate on common property resources and, without management, are subject to an innate tendency to become economically and often biologically over-exploited. Fisheries management has developed a number of tools to combat this tendency. Functional management measures (for use when fisheries objectives are being broadly met) may include:

- direct conservation measures designed to curb exploitation such as limits to catch and fishing effort (the product of fishing capacity and usage);
- technical conservation measures designed to modify exploitation patterns so as to avoid capture of underage or vulnerable life-history stages such as mesh regulations, minimum landing sizes, closed area, closed seasons and gear restrictions;
- economic conservation measures designed to address the economic drivers of over exploitation such as extraction taxes, individual property rights (e.g. individual transferable quotas) and consumer education;
- social conservation measures designed to increase compliance with regulations such as traditional usage rights, co-management and education of fishers.

Ecosystem management extends the concerns of fisheries management to the health of the whole system whether or not various components are targets of exploitation. Given the lesser knowledge available for non-target species and hence greater uncertainty, ecosystem management lays greater stress on the need for a precautionary approach and management that adapts to changing circumstances**.** It regards human activities as an integral part of the ecosystem and stresses the need for the involvement of all stakeholders. Functional ecosystem management measures (for use when ecosystems objectives are being broadly met) include those used by fisheries management but with broader intentions and swifter and more stringent application:

- direct conservation measures designed to curb exploitation both in total and in geographical spread such as fishing effort (the product of fishing capacity and usage and area) limits, and target catch limited by the take of by-catch species;
- technical conservation measures designed to modify exploitation patterns so as to reduce capture of vulnerable species or vulnerable life-history stages of species such as no take zones, marine parks, gear restrictions, adaptations of gear and fishing practice;
- economic conservation measures designed to address the economic drivers of ecosystem degradation such as extraction taxes and consumer education (to work through consumer choice influencing the market);
- social conservation measures designed to bring social pressures to bear on problems associated with the marine environment such as traditional usage rights, co-management, education of fishers.

The above measures are appropriate when fish stocks and ecosystems are regarded as being in reasonable shape or at least not at risk of collapse**,** and continued exploitation is appropriate i.e. when the system is close to its TRPs and well within the LRPs. They should be bolstered by additional or alternative measures when the system falls outside or approaches rapidly the LRPs (management beyond limit reference points). The most stringent (and most controversial) of these management measures for possible application beyond the LRPs are

moratoria, but less drastic means may be appropriate if the resources are not far outside the limit reference points. Artificial propagation may provide a palliative for reduced stock reproduction but is not, for various reasons, a solution to over-exploitation.

Thus aquatic species may be protected by various possible management arrangements. These require a national will to create laws and to enforce them and a willingness on the part of the stakeholders to abide by them. However, both requirements are reasonable expectations of societies that permit exploitation of living aquatic resources, and these management arrangements should be the first and best suite of tools for conserving species and ecosystems.

3.3 Species for which CITES listing is a priority

In considering the CITES criteria for listing exploited aquatic species, it is necessary to consider the intended role of CITES and how it is related to other fisheries management instruments or systems with overlapping functions. Fisheries management is intended to conserve exploited resources and provide social and economic benefits from them. If a given management system is functioning as intended, here referred to as functional fisheries management, it tends to look after those species which are captured for commercial use (and hence have direct human value) or for subsistence. It is likely to be more successful with species which are reasonably robust to exploitation (can sustain themselves under fairly substantial fishing pressure) and when its rules are sufficiently well enforced and compliance is high. The same could be said of functional ecosystem management, although this is also intended to look after species that although possibly affected or killed by fisheries are neither marketed nor consumed and as such have no value in trade. In the following discussion, "value" is used to refer to value in commerce or for subsistence. Species may alternatively have no direct value to humans but have substantial value to biodiversity and ecosystem functioning. Moreover, ecosystem management measures may sometimes be more easily enforced and complied with (e.g. marine protected areas, at least in coastal areas), particularly when they do not have a substantial negative impact on operations and profitability.

It should be noted that the FAO Code of Conduct (FAO 1995) requires that responsible fisheries management includes conservation of the ecosystem. For example, Paragraph 6.6 of the Code of Conduct states that “Selective and environmentally safe fishing gear and practices should be further developed and applied, to the extent practicable, in order to maintain biodiversity and to protect the population structure and aquatic ecosystems..”. Other references to an ecosystem approach can be found in, *inter alia*, paragraphs 6.8, 7.2.2, 7.2.3 and 7.6.9. Therefore, in the modern context functional fisheries management should always incorporate functional ecosystem management. However, there will be instances where functional ecosystem management is occurring but without the implementation of the more traditional and stock-focused functional fisheries management (see Figures 2 and 3).

Both these systems of management allow management agencies to regulate impacts on marine species, satisfying human and ecosystem needs, when the aquatic populations (and mortality on them) are maintained at sustainable levels. When populations become reduced beyond biological limits, when mortality levels have become excessive, or when the social and economic benefits being realised from the fishery fall outside reasonable and sustainable limits, the management of the concerned sub-populations of species (i.e. stocks) should shift to management beyond limit reference points. In practice these more stringent measures most frequently become necessary when conventional (and precautionary) management targets and

limits have been systematically violated, or inappropriately set, which generally occurs long before a species is at any risk of extinction *stricto sensu*. Timely and effective implementation of corrective measures (including habitat restoration and stock rebuilding strategies) is essential if the benefits potentially offered by the system are to be restored and the conservation requirements satisfied.

Problems arise when high levels of profitability (or lack of alternative opportunities), encourage the systematic violation of the rules of functional management and management beyond limit reference points for species which are biologically vulnerable (with low resilience) and in cases where the fishery systems are unable to ensure compliance with management regulations. In these cases, conventional management alone may fail and additional measures, extending beyond the normal jurisdiction of fisheries management, such as the CITES mechanism to curb trade and hence to reduce value, are appropriate. Hence the species most at risk of extinction and for which criteria for listing under CITES might therefore be more closely examined would be those:

- which allow particularly profitable operations (high prices and/or low costs);
- which are highly vulnerable to exploitation because of their life-history; and
- for which normal management rules are non-existent or systematically violated.

Table 3 illustrates some of the features of these different regimes for managing marine species.

For illustrative purposes the dimensions of this table can be collapsed into three main factors 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**.
- **"violability"[3]:** related to the extent to which conventional management measures may be circumvented, this factor could also be called **compliance risk**.
- **value:** related to the profitability of the species' exploitation, this factor could also be called **economic risk**.

If the three sources of risk are scaled from "Low" to "High" and if we assume that they add-up (or reinforce each other) the overall risk resulting from their interaction can be represented conceptually in a three-dimensional risk space delimited by bio-ecological, compliance and economic risk (Figure 2). The figure illustrates the fact that the overall composite risk to the resource (and ultimately to the fishery) increases from the low left-hand to the high right-end corner of the diagram.

[3] From "violable": which can be violated.

Table 3: Some of the features of the different regimes for managing marine species

Management regime	**Catch** • Target • Non-target catch and discards	**Population**	**Value**	**Rules**	**Viable levels of % removal**	**Actual levels of removals**
Functional fisheries management	• High • Directly or indirectly regulated	Target stock viable and estimable	Operates where commercial value is moderate to high	Complied with to a reasonable extent	Usually quite high	Not above estimated viable level
Functional ecosystems management	• High • Regulated	Multispecies stock viable Biodiversity maintained	Operates to conserve ecological value, rather than focusing on commercial value	Complied with to a reasonable extent	Variable, related to environment and productivity	Not above estimated viable level
Management beyond limit reference points	• Low to zero • Low to zero	Reduced beyond limit reference points	Operates where stocks are damaged and threatened. Commercial value can still be high	Stricter and more stringent (e.g. moratoria)	Low or nil (priority to stock recovery)	Low or nil (stricter enforcement)
International trade measures (CITES)	Both are dependent on local demand as there is no international trade	Growing and real threat of extinction of species	Operates where high potential residual trade value	Only international trade is regulated	Zero or very low. However, not directly regulated by CITES	Dependent on demand without international trade. Risk of unlawful take and trade

Conceptually, all exploited species can be positioned along the "vulnerability" axis, depending on their population dynamics and life-history characteristics. Their dependence on critical habitats will also influence their degree of vulnerability. For example, small pelagic species will occur close to lowest end of the vulnerability category while, for example, whales, sturgeons, precious corals, or lobsters will lie close to the highest end. It should be noted that the "intrinsic" place of the species on the vulnerability axis will generally be shifted towards a higher vulnerability point by increasing exploitation rates, particularly as the resources are depressed below their biologically acceptable limits in terms of the number of surviving age classes, the range of distribution or simply reduced abundance. Hence, vulnerability is a dynamic property, not a static characteristic. When a species or population is considered within a fishery or fisheries, and hence within a specific socio-economic and management context, the species-fishery complex will occupy a specific position within the three-dimensional risk space represented by Figure 2. Low vulnerability species will avoid the highest risk upper right-hand

corner of the diagram, while species with high vulnerability and value will be at greater risk of being shifted into this zone by exploitation. It is clear that the highest risk for the resources (and at the extreme, the risk of extinction) and the area of greatest potential effectiveness of international trade measures is where all three factors are at their highest level.

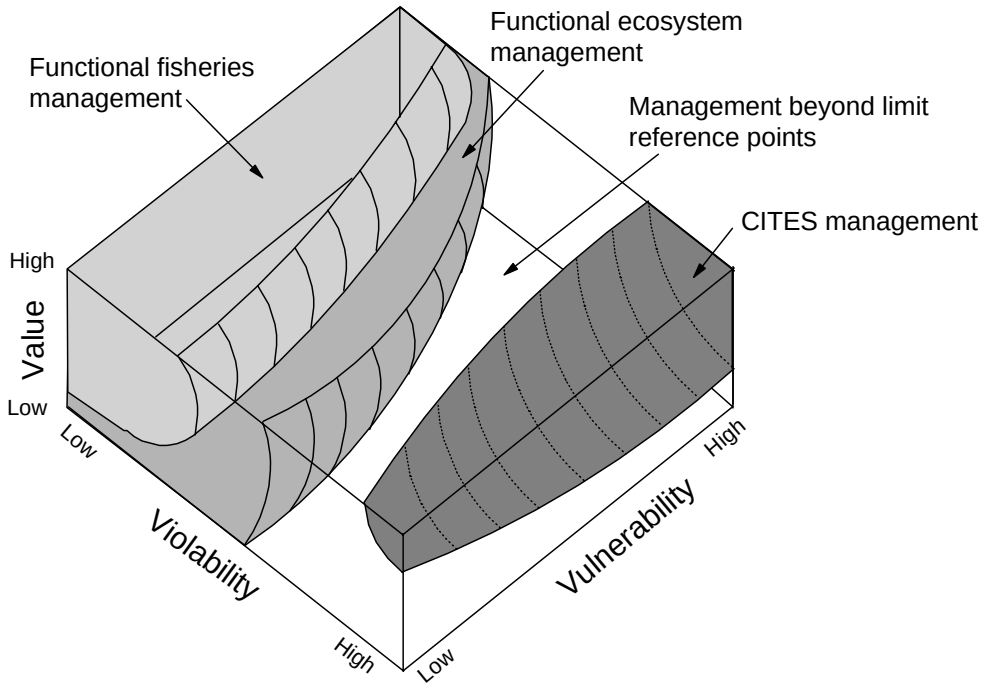

Figure 2. Conceptual area of relevance for effective functional, ecosystem and crisis management and international trade restrictions based on the risk to the resource, where the total risk is represented by the sum of vulnerability, value and violability. The figure applies to exploited resources

Figure 3 is intended to facilitate interpretation of Figure 2. It clearly illustrates that while functional fisheries management is part of functional ecosystem management, it may become less relevant and effective at low resource value (where economic incentive is low or nil). Also reflected in the figures is that as value increases, the effectiveness of both fisheries and ecosystem management increase as interest in the species increases and the revenues to pursue its effective management similarly increase. However, at very high values, the incentive for deviation from regulations increases, leading to a decrease in effectiveness. This latter feature clearly reflects a correlation between value and violability. The figures also show that when both management types fail and the population and fishery fall outside the defined reference points, the species moves into an area requiring more stringent measures, the area of management beyond limit reference points. Finally, it shows that, as an exceptional measure dictated by exceptional conditions, trade measures are an extreme form of management with an important role to play when the composite risk is highest.

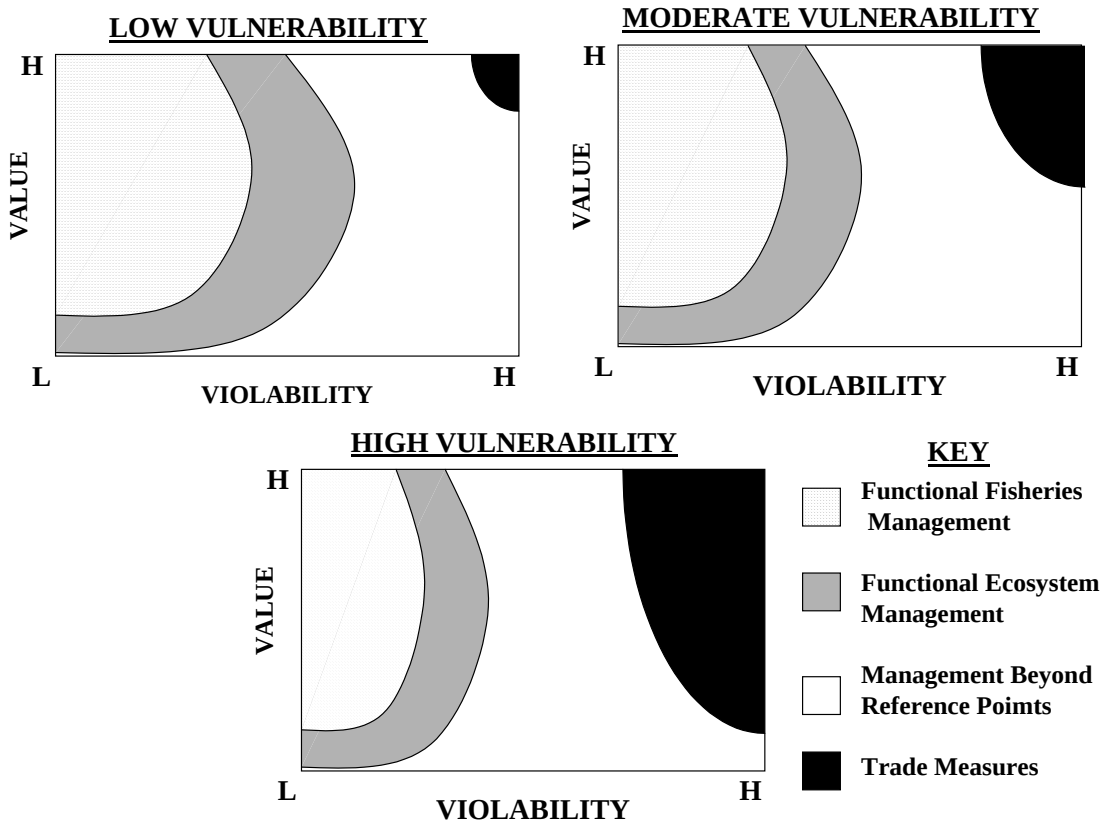

Figure 3. Two-dimensional sections across the "Vulnerability" axis of the 3-dimensional risk space shown in Figure 2, indicating the relative roles of functional fisheries and ecosystem management, management beyond limit reference points and the role of trade measures, according to the total risk on a species or population

As reflected in Figures 2 and 3, the functional mode of fisheries and ecosystem management perform better in the region where species are less vulnerable and compliance is good. Fisheries management, however, may not be very effective for species with very low or zero market value (such as discarded or benthos species) which are better dealt with through ecosystem management as part of the biodiversity and environmental conservation package. Ecosystem measures (e.g. marine protected areas) might also be more effective to protect species when compliance with conventional measures (e.g. mesh size regulations) is low. The mode of management beyond limit reference points, with exceptional and more stringently enforced measures, is required when species have moved or been driven into a higher risk area by mismanagement (non-functional conventional or ecosystem management) or environmental factors or a combination of both. Its effectiveness is likely to decrease, however, as the incentive to violate the rules increases with the value of the species (boosted by scarcity). Populations for which all three factors are high (naturally or because of fishing pressure) and which present a

significant risk of extinction would require additional incentives to ensure better compliance, such as international trade restrictions.

The above description implies that populations or stocks will only enter the zone of sufficiently high risk of vulnerability, violability and value to warrant international trade measures if there is a failure in fisheries or ecosystem management in that case. This scenario is considered to be applicable to the vast majority of populations and stocks of living aquatic resources. However, it is also recognised that in some exceptional circumstances, a high degree of vulnerability, coupled with very high value and opportunity for violations may mean that even in its pristine state, a population would require trade measures for its protection. Such cases are very rare, but an example could be the red corals, which have very high value, very low levels of production and are generally in easily accessible habitats.

In addition, attention, needs to be drawn to the common deficiencies, in practice, with management beyond limit reference points. It should be clear from the definition of this zone and the arguments above, that once a fishery-species complex enters this zone, especially stringent management and regulations should automatically be brought into effect, with recovery of the resources to levels above the LRPs as the highest priority goal. However, many fisheries do not have well defined LRPs or management ignores these points when the stock falls below them and continues to operate normal management measures, perhaps aiming at yields that will maintain the status quo, instead of facilitating recovery of the depleted stocks.

Another common attitude to stocks which have been depleted for a number of years, is to come to regard the new depleted status as the normal or target level and to gradually adjust to attempting to make maximum use of the fish production at the low level. These adjustments in expectations of the returns from the stock perpetuate the problem of over-exploitation, not allowing enough of the production to contribute to population growth to encourage recovery. The danger here, of course, is that the risk is much higher than when within the limit reference points. From that point, it can take only a few years of poor recruitment, or a number of relatively minor assessment errors, and the stock is driven even lower and the risk of extinction may become of real concern. In this regard, it is worth referring to the Code of Conduct which specifies, "States and .....fisheries management organisations and arrangements... should introduce measures for depleted resources and those resources threatened with depletion that facilitate the sustained recovery of such stocks" (Paragraph 7.6.10).

Thus there is a danger that the zone of management beyond limit reference points can become a zone of normal operation, with attendant high risk to the resources. Under these circumstances, there may be a temptation to expand the zone of regulation by trade measures to encompass these fisheries. As a last resort, and if international trade is a meaningful part of the fishery, this could be justified. However, given the limitations of trade restrictions in effecting sustainable utilisation, a far more effective route would be for fisheries management organisations to adhere to the Code of Conduct and take the necessary steps, as required in management beyond limit reference points, to encourage the recovery of the depleted stocks.

It should be clear from this reasoning that international trade restrictions (i.e. through listing in CITES) would be most relevant where the three V's (and resultant risks) are high and the stock considered is well below safe levels with high probability of extinction. In general, many species-fishery combinations which exhibit all these characteristics have indeed been shown to be highly susceptible to over-exploitation and should therefore be regarded as priority cases for evaluating against the CITES criteria for listing. Correspondingly, because of the

inherent uncertainty in marine open systems, in cases where the three V's are known to be high, the guidelines to the criteria for establishing their proximity to extinction (see section 4) should be interpreted generously (i.e. in a precautionary mode). Conversely, in the case of endangered species that have little market value, a CITES listing, although it might give some additional moral force to the requirement for their conservation, is likely to be of limited effectiveness in providing additional protection and other extreme conservation mechanisms might then be needed. For instance, national endangered species legislation, bolstered by educational and economic incentives for their preservation (e.g. encouraging reduced impact), may be a more effective approach.

4 EVALUATION OF CITES CRITERIA WITH RESPECT TO THEIR APPLICABILITY TO EXPLOITED MARINE SPECIES

4.1 Approach to the evaluation

CITES is designed to protect species threatened with extinction where trade in the species at risk does or may contribute to the risk, perpetuate it, or increase it. CITES typically operates at a species level, whereas fisheries management typically operates at the level of individual stocks.

The CITES documentation (CITES, 1994) provides criteria for listing species and hence for restricting trade in them. These criteria are supported by a series of definitions of key words. Criteria and definitions are found separated in Annexes 1 and 5 respectively. It is impossible to evaluate the appropriateness of the criteria for marine organisms without addressing how key words in the criteria are defined, and in this review aspects of the definitions along with the criteria themselves are discussed. In fact, some nuances of terminology contained in the definitions in CITES Annex 5 are sufficiently central to interpreting the intent and applicability of the criteria, that consideration should be given to incorporating elements of the definitions in this Annex 5 directly into the listing criteria in CITES Annex 1. This would clarify the intent of the criteria and allow users of the criteria to feel more secure in their interpretations of specific cases. This latter point is particularly significant in the light of the discussion in Section 3, regarding the distinction between using listings to actually have an impact instead of merely signaling strong concern.

In the past, these criteria have mostly been applied to large mammals, birds and reptiles. In considering how these criteria might be adapted for use with exploited aquatic animals, it is first necessary to consider how they would be applied in their current form, and what sorts of problems, if any, would result. Potential problems would guide users to modifications needed to adapt the criteria to the special circumstances of the aquatic environment. In particular, perfect criteria would always assign species at risk of extinction to categories which ensured trade in those species was restricted. In addition, because trade is an important human activity, perfect criteria would also avoid classifying species that were not at risk of extinction to categories which required unnecessary trade restrictions. Because the world is imperfect, any criteria will run some risk of producing false alarms (classify species which are not at risk of extinction to a category requiring trade restrictions) and misses (fail to classify species at risk into categories offering them necessary protection from trade). Good criteria will minimise both sources of error and the criteria are evaluated with this in mind.

In evaluating potential errors of applying the criteria, however, it should be kept in mind that the consequences of errors are not symmetric, nor are costs of errors shared equally among

all concerned parties. False alarms provide protection to a species which is not truly at risk of extinction, but as noted in Section 3 may still be subjected to poor fisheries management. To conservation advocates this may not be perceived as a bad thing. However, the unnecessary prevention of trade may have severe economic consequences for harvesters or coastal states, particularly where alternative sources of trade may be limited, or where the market opportunity may be lost indefinitely. The look-alike provisions can multiply the negative consequences of a false alarm greatly, if trade restrictions are then applied to related species as well, or to populations of the same species elsewhere. Misses, on the other hand, would allow trade to continue in a species at risk of extinction, and the associated mortality or live removals from the population could result in the population falling to a size which is not viable. The resultant extinction would be a loss both in the context of conservation of biodiversity and all future economic value. This extreme cost of misses is captured in CITES Annex 4A, which follows the precautionary principle in acknowledging that “the Parties shall, in the case of uncertainty, ... act in the best interest of the species.” The following evaluation of criteria is conducted cognizant of this important asymmetry in costs and consequences of misses and false alarms.

4.2 The Criteria dealing with Trade

CITES criteria dealing with trade rely on several articles of the CITES convention. Article I defines Trade as export, re-export, import and introduction from the sea (Box 5). Article II indicates the extent that Trade should be involved in order that a species should be listed (Box 6).

BOX 5: DEFINITIONS EXTRACTED FROM ARTICLE I

For the purpose of CITES Convention, and unless the context otherwise requires:

(a) "Species" means any species, subspecies, or geographically separate population thereof;

(b) "Trade" means export, re-export, import and introduction from the sea;

(c) "Re-export" means export of any specimen that has previously been imported;

(d) "Introduction from the sea" means transportation into a State of specimens of any species which were taken in the marine environment not under the jurisdiction of any State;

BOX 6: CITES ARTICLE II

Fundamental Principles

1. Appendix I shall include all species threatened with extinction which are or may be affected by trade. Trade in specimens of these species must be subject to particularly strict regulation in order not to endanger further their survival and must only be authorized in exceptional circumstances.

2. Appendix II shall include:

(a) all species which although not necessarily now threatened with extinction may become so unless trade in specimens of such species is subject to strict regulation in order to avoid utilization incompatible with their survival; and

(b) other species which must be subject to regulation in order that trade in specimens of certain species referred to in sub-paragraph (a) of this paragraph may be brought under effective control.

3. Appendix III shall include all species which any Party identifies as being subject to regulation within its jurisdiction for the purpose of preventing or restricting exploitation, and as needing the co-operation of other Parties in the control of trade.

4. The Parties shall not allow trade in specimens of species included in Appendices I, II and III except in accordance with the provisions of the present Convention.

The 1994 (Fort Lauderdale) resolution provides further clarification on the definition of species affected by trade (Box 7).

BOX 7: CITES COP 9th MEETING (Ft. Lauderdale, CITES 1994)

RESOLVES that, when considering proposals to amend Appendices I and II, the following applies:

a) any species that is or may be affected by trade should be included in Appendix I if it meets at least one of the biological criteria listed in Annex 1;

b) a species "is or may be affected by trade" if:

i) it is known to be in trade; or

ii) it is probably in trade, but conclusive evidence is lacking; or

iii) there is potential international demand for specimens; or

iv) it would probably enter trade were it not subject to Appendix-I controls;

The 1994 resolution also provides clarification of look-alike species. The appraisal of the criteria for look-alike provisions is dealt with in subsection 4.6 below. However, there is a need to consider the extent that the term “in trade” is or might be interpreted. In Section 2 it is noted that the two main types of marine species for which exploitation is likely to contribute importantly to risk of extinction are:

- highly valued target species which are directly sought by fishing, and;
- associated species which are vulnerable because they are caught as a by-catch or suffer incidental mortality during the exploitation of other targeted species.

Species in the former group are clearly appropriate to listing in CITES Appendices I or II. Similarly, the species in the second group are clearly covered by CITES listing, if, when taken

by chance, they are marketed. However, the trade that chiefly endangers the second type of species is the capture and subsequent marketing of the target species of the fishery for which the species at risk forms a minor or disregarded by-catch.

The question is already being debated in some quarters, if trade in such target species should be included in a listing of species under trade restrictions, in order to offer important protection to the species at risk taken as bycatch. A detailed consideration of this question would conclude that the ramifications of such an approach to listing could expand so widely as to render trade regulations for conservation objectives inoperable. Such an interpretation of listing criteria also would have significant implications for terrestrial as well as marine listings. It is therefore concluded that the practice of listing only species at risk of extinction, and where necessary "look-alikes", should not be extended to non-threatened target species whose exploitation endangers other species. Such problems should be dealt with by instruments other than international trade restrictions.

4.3 Consideration of Criterion A

4.3.1 Statement of Criterion

Criterion A for listing a species as at risk of extinction requires that:-

A. The wild population is small, and is characterized by at least one of the following:

i. an observed, inferred or projected decline in the number of individuals or the area and quality of habitat; or

ii. each sub-population being very small; or

iii. a majority of individuals, during one or more life-history phases, being concentrated in one sub-population; or

iv. large short-term fluctuations in the number of individuals; or

v. a high vulnerability due to the species' biology or behavior (including migration).

4.3.2 Points to note from the definitions

In all CITES criteria, population refers to the total number of the species and sub population refers to what in fisheries management terms would usually be regarded as a stock.

One important concern with the "small" population sub-criteria is what constitutes biologically "small" for aquatic fish and invertebrate species, and "very small" for each sub-population. The values of 5,000 individuals and 500 are suggested in the CITES guidelines and definitions (note these are designated as guidelines not thresholds).

4.3.3 Evaluation of the Criterion

A considerable literature exists on the subject of what population levels must be maintained if a species is to avoid the risk of extinction in a short time period. A particularly clear exposition of these can be found in Caughley (1994). The concept of Minimum Viable Population (MVP) is developed from considering three main processes that might lead to the extinction of small populations. These are

- demographic stochasticity, (e.g. by random fluctuations a small subpopulation only producing male offspring and hence dying out);

- environmental stochasticity (i.e. vital rates varying with environmental changes);
- genetic (e.g. inbreeding) considerations.

While the numbers of 5000 and 500 are clearly very small by most fisheries management standards they are based on general results from the conservation biology literature. Hence, they may be accepted as generally appropriate for marine species, in the specific context that they are large enough to indicate a sufficiently low probability of extinction due to both demographic and environmental stochasticity. There are, however, features of marine systems that need to be taken into account more fully when evaluating specific cases relative to the CITES guidelines for numbers of individuals. In particular, consideration needs to be given to the diversity of life-history strategies found in marine species (Section 2), and difficulties in sampling fish and aquatic invertebrates, in comparison to sampling populations of terrestrial vertebrates. Several specific concerns will usually have to be addressed when applying Criterion A to aquatic fish and invertebrates.

First, the numbers must be taken as applying to mature organisms with reasonable opportunity to reproduce. Concerns about demographic stochasticity may require larger minimum populations if the species shows extremely specialized breeding systems. In some lekking species very few mature individuals of one sex have the opportunity to reproduce (walrus). In species which change sex with age, one sex may be much rarer than the other (some shrimps, reef fish). Either situation could produce genetic bottlenecks when total numbers of mature individuals are in the hundreds to a few thousands (Burgman *et al*. 1993).

Second, the difficulties in estimating sizes of populations of marine organisms mean that one cannot assume equal precision of estimates of numbers of fish compared to birds or mammals. At the low numbers indicated by the guidelines, many marine species would become almost impossible to count, and estimates of their numbers would have very large error bounds. As an example of sampling difficulties, a species of fish will essentially disappear from typical fishing surveys when its abundance is still far above any reasonable threshold for “small”. Hence, if one is to be confident that there is an acceptably small risk of extinction due to stochastic factors, the guideline listing values of <5,000 for the population and <500 for sub-populations are better taken as lower bounds of confidence intervals or likelihood profiles, rather than the mean estimate of the population size.

Thirdly, populations in the sea may be widespread. Thus, these numbers give the possibility of the dilution of a wide ranging population to very low densities across its range. For some species, numbers far higher than any guideline values for “small” will be at densities so low that successful pairing is unlikely. This would be particularly the case for sedentary species (e.g. abalone).

Fourthly, there are special problems interpreting the second sub clause of the criterion Aii). What is meant by “each” versus “any” must be viewed carefully (see also relative to criterion B). Although 5000 individuals may provide a sufficiently comfortable margin for the species, sub-populations of 500 seem too small for all but the largest species of marine creatures. There are several reasons for this concern. Social behaviors of birds and mammals mean individuals may gain benefits of reduced likelihood of mortality when they are members of groups of as many as 500 individuals. This is not as likely to be true for fishes and invertebrates. Exploitation (and hence trade, the reason why CITES is involved at all) of birds and mammals is likely to be on individuals; marine species may be exploited in clusters (schools, spawning aggregations, etc.). Hence, groups and therefore sub-populations may need to be larger than is

the case for terrestrial animals, in order for them to have equal likelihood that any given percentage will survive one exploitation event. Moreover, environmentally caused mortality is more likely to be correlated across sub-populations of marine species than terrestrial species (Dickson *et al*. 1998, Francis *et al*. 1998). Population Viability Analysis (PVA) shows that as the correlation of environmental stochastic events goes up across metapopulations, the risk of extinction also goes up. Hence, to keep any risk of extinction to acceptably low levels suggests the minimum of sub-population size has to be increased for marine species. Perhaps a guideline of 2000 would be appropriate, but this value is the result of professional judgment and not formal analysis.

Hence, the major concern with CITES criterion A, as written, is that in some cases it may allow dangerous misses. If the guidelines are applied so rigidly that it sets too high a minimum number of individuals for species which have highly vulnerable life-histories, it may prevent the listing of species which are at risk of extinction. Indeed, one might suspect that for marine species, the condition of the opening clause might often be considered sufficient for listing, if it was clear what "small" was for the species of concern.

4.4 Consideration of Criterion B

4.4.1 Statement of Criterion

Criterion B for listing a species as threatened with extinction requires that:-

B. The wild population has a restricted area of distribution and is characterized by ***at least one*** *of the following:*

i) fragmentation or occurrence at very few locations; or

ii) large fluctuations in the area of distribution or the number of sub-populations; or

iii) a high vulnerability due to the species' biology or behaviour (including migration) ; or.

iv) an observed, inferred or projected decrease in any one of the following: the area of distribution; the number of sub-populations; the number of individuals; the area or quality of habitat; reproductive potential.

4.4.2 Points to note from the definitions

Area of distribution

Area of distribution is defined as the area contained within the shortest continuous imaginary boundary which can be drawn to encompass all the known, inferred or projected sites of occurrence, excluding cases of vagrancy (though inferring and projecting area of occurrence should be undertaken carefully, and in a precautionary manner). The area within the imaginary boundary should, however, exclude significant areas where the species does not occur, and so in defining area of distribution, account should be taken of discontinuity or disjunction in the spatial distribution of species. For migratory species, the area of distribution is the smallest area essential at any stage for the survival of that species (e.g. colonial nesting sites, feeding sites for migratory taxa, etc.). For some species in trade where data exist to make an estimate, a figure of less than 10,000 km^2 has been found to be an appropriate guideline (not a threshold) of what

constitutes a restricted area of distribution. However, this figure is presented only as an example, since it is impossible to give numerical values that are applicable to all taxa. There will be many cases where this numerical guideline does not apply.

Fragmentation

Fragmentation refers to the case where most individuals within a taxon are found in small and relatively isolated sub-populations, which increases the probability that these small sub-populations will become extinct and the opportunities for re-establishment are limited. For some species in trade where data exist to make an estimate, an area of distribution of 500 km^2 or less for each subpopulation has been found to be an appropriate guideline (not a threshold) of what constitutes fragmentation. However, this figure is presented only as an example, since it is impossible to give numerical values that are applicable to all taxa. There will be many cases where this numerical guideline does not apply.

4.4.3 Evaluation of the Criterion

Although the definition states that a common area of distribution guideline cannot be applied to all taxa, the guideline of 10,000 km^2 could be considered too small for many marine species. Too rigid an adherence to the guideline might therefore lead to misses, with species at risk of extinction not being listed. This danger of misses can be compounded for species with discontinuous distributions, such as around sea mounts, oceanic islands, or coral reefs. In such cases, an area as large as 100,000 km^2 might include very little suitable habitat for the species of concern, and these patches of habitat might be separated by large areas of unsuitable open ocean. The acknowledgement that risk of extinction can be increased when a species' distribution is highly fragmented is frequently very relevant to evaluating the status of marine species. On the other hand, some marine fish and invertebrates are broadcast spawners (see Section 2), capable of disseminating fertilized eggs widely through use of marine currents. These complexities are part of what determines the vulnerability of species to depletion. As noted in Section 3, and in the discussion of Criterion A, vulnerability of the species potentially at risk is one of the important factors in determining how strictly or generously the guidelines on area (and abundance) should be interpreted.

Although there are concerns about the potential for misses, with a typical interpretation of the guidelines, this criterion is not likely to lead to numerous false alarms; listing of species for which some appreciable risk of extinction does not exist. Indeed as with CITES criterion A, the initial condition of very limited range would almost suffice for discouraging the harvesting of a marine species, unless a great deal were known of its biology and there was confidence that management would be effective (i.e. low violability). Again, as with the discussion of the abundance criterion A, the low potential for false alarms needs to be viewed in the context of difficulties of sampling marine populations. In typical marine fish surveys, uncommon species may be present in very few of the samples. The conclusion that a species has actually ceased to be present in an area it once occupied should be based on sufficient survey effort to have a reasonable probability of detecting the species of concern if it were there. Analytical approaches for estimating such probabilities have been developed, but are frequently not applied in the analysis of fisheries survey data. They would be important when using survey data to evaluate a species relative to several considerations on CITES Criteria B4; observed, inferred or projected decrease in area of distribution or number of subpopulations.

4.5 Consideration of Criterion C

4.5.1 Statement of Criterion

Criterion C for listing a species as threatened with extinction requires that:

C: A decline in the number of individuals in the wild, which has been either:

i) observed as ongoing or as having occurred in the past (but with a potential to resume); or

ii) inferred or projected on the basis of any of the following:

a decrease in area or quality of habitat; or

levels or patterns of exploitation; or

threats from extrinsic factors such as the effects of pathogens, competitors, parasites, predators, hybridization, introduced species and the effects of toxins and pollutants; or

decreasing reproductive potential."

4.5.2 Points to note from the definitions

From the definitions and guidelines, declines of 50% in numbers of the species as a whole, or 20% of small population units are suggested as guidelines, and it is acknowledged that these percentages should not be used as rigid thresholds. The definitions also explicitly note that natural fluctuations are not to be considered declines, nor are decreases in abundance which are part of planned management regimes.

4.5.3 Evaluation of the Criterion

It is the decline criterion C which presents the greatest problems for applications to marine harvested species. Some of the problems are just difficulties of implementation, whereas others are difficulties of principle. The core concern is that the decline criterion is likely to allow too many false alarms. Even allowing for the qualifications in the definitions, there are likely to be many marine species that will be considered to have experienced declines sufficiently large to warrant listing but for which the population remains at a size where there is negligible risk of biological extinction. Listing such species could cause unnecessary social and economic disruption and would weaken the moral force of CITES' listing of those species which are truly at risk of extinction. Moreover, the look-alike provision of CITES might well compound the error, as the end-products in trade of many fish species are difficult to differentiate except by specialized techniques.

To some extent, the concerns over the decline criterion follow from failure, or fear that others will fail, to take seriously enough the admonition that declines which are natural fluctuations or due to planned harvests of accumulated standing biomass are not covered by "decline". Such failures and fears are not wholly unjustified, however, given the complexity of population dynamics of marine populations, and the instructions in the definitions and guidelines that "an observed decline should not be considered part of a natural fluctuation unless there is evidence for this". In practice these two factors may remove application of this criterion from the domain of objective scientific discourse. Even when millions of dollars have been spent on directed research and monitoring, it may be impossible to untangle the variety of possible causes

of dramatic declines in abundance of fish stocks (DFO 1999). Determining what is “evidence” that a decline reflects a natural fluctuation and how much “evidence” is needed invites debate among advocates of divergent interpretations of population declines.

The problems with the decline criterion are not simply ones of inconclusive scientific research about causes of a decline, however. As developed in section 2, differences in the survivorship schedules and potential fecundity of species of marine fish and invertebrates can be used to bring some order to interpreting what a decline of any fixed percentage means for a species. The lower the total numbers for a species, the more serious are the implications of a given decline for population viability (Burgman *et al*. 1993, Yablokov and Ostroumov 199?). Nonetheless, simply treating 50% and 20% as particularly labile guidelines does not ameliorate the problems of application of a decline criterion. The magnitude of an observed or inferred decline is rarely at the center of a debate. Rather disagreements may focus on what caused the decline, whether the causes have been controlled adequately, and what the decline means for population viability.

Despite the problems with both the concept and implementation of a listing criterion based solely on population decline, there is the possibility that there will be valid cases where no other criterion is available. In some cases the only information on a species is the frequency with which it appears in an international market. An example would be a species known only to be of coastal South Pacific origin, that is sold in a specialist aquarium market. In this case, nothing might be known of exactly where the species is caught, how widespread it is or was, and what its true abundance has ever been. If its frequency of availability in the market dropped from many individuals available daily to individuals appearing infrequently, it might be inferred that it was threatened and trade restrictions might be a desirable and effective conservation tool. Hence, total abandonment of a decline criterion - in this case inferred decline based on market statistics - eliminates access to a valuable (and possibly only) conservation tool.

Hence, a dilemma exists with the decline rule. This is, that in many cases the decline rule could lead to listing species which are not at risk, but its abandonment would risk failing to list some species that might well be at risk. Fortunately, by clarifying when the decline criterion is an appropriate tool - only when no other information on a species is available - a possible approach is suggested to deal with its undesirable property of triggering too many false alarms.

For exploited marine species, it is proposed that the criterion should be modified to the following rationale. If a species is capable of evaluation on CITES Criteria A and/or B and fails to qualify under either criterion as being at unacceptable risk of extinction, then it should not qualify for listing on the decline criterion alone. However, if no data exist to apply either Criterion A or B, then evaluations based on only Criterion C would be based on the best scientific information available.

This approach has several desirable properties. It is consistent with the precautionary approach. When there is great uncertainty about the status of a species, it allows conservation measures to be taken before the uncertainty has been resolved. At the same time, as more information is acquired on the actual abundance and distribution of a harvested species, the approach places the emphasis on using that information fully. Moreover, it encourages appropriate data to be collected to estimate either the minimum population size and/or the area of distribution, such that the species can be evaluated on CITES criteria A and/or B. Clearly, this approach places the onus on fishery managers whether at the national or international level to

collect information on fisheries under their jurisdiction, and rewards them with less risk of inappropriate CITES listings when this information is provided.

The approach proposed above suggests further refinement to the listing criteria that might be useful to explore. In particular, it may be appropriate to set somewhat higher thresholds for the lower limit estimates for criteria A and B (small numbers or range) where these factors are used to exclude from listing a species which would otherwise qualify on CITES criterion C. Whether different thresholds would be necessary to maintain some agreed degree of risk aversion relative to extinction, when a decline of say 50% over 10 years had been documented, would require simulation studies that are impossible in the time available for this review. As a minimum, however, the criterion should be written so that use of the exception clause places management institutions on notice that they would have to provide evidence that a qualifying downward trend had been controlled. If this were not the case, clauses Bi or Bii of Criterion D may be applied and the species listed under Appendix II.

4.6 Consideration of Criterion D

Criterion D allows species which do not satisfy criteria A-C to be nonetheless listed under Appendix I in accordance with Article II.

4.6.1 Statement of Criterion

"The status of the species is such that if the species is not included in Appendix I, it is likely to satisfy one or more of the above criteria within a period of five years."

4.6.2 Points to note from the definitions

See comments under A-C

4.6.3 Evaluation of the Criterion

The terms of criterion D build from criteria A-C and preceding comments under these would also apply to proposed listings under Appendix II.

4.7 Criteria for Appendix II listing under Article II Paragraph 2a of CITES

These criteria allow Appendix II listing when it is expected that :-

- The Appendix I criteria A-C will be met in the near future (longer than five years), or
- The conditions of exploitation are beyond sustainable levels.

4.7.1 Statement of Criterion

A species should be included in Appendix II when either of the following criteria is met.

A. It is known, inferred or projected that unless trade in the species is subject to strict regulation, it will meet at least one of the criteria listed in CITES Annex 1 (see Annex 2 of this document) in the near future.

B. It is known, inferred or projected that the harvesting of specimens from the wild for international trade has, or may have, a detrimental impact on the species by either:

> *i) exceeding, over an extended period, the level that can be continued in perpetuity; or*

ii) reducing it to a population level at which its survival would be threatened by other influences.

4.7.2 Evaluation of the Criterion

The wording of Annex 2a Bi , regarding harvesting having exceeded, over an extended period, the level that can be continued in perpetuity, presents no conceptually new problems, relative to issues discussed under criteria for listing under Appendix I. However, as with issues discussed in regard to Appendix I, to minimize both false alarms and misses with this criterion requires good judgment and good faith in interpreting “extended period” and “continued in perpetuity”.

There are many reasons why in retrospect, one might conclude that mortality on a species caused by fishing is likely to have exceeded a sustainable rate for a number of years (Sinclair *et al.* 1991). Debate about listing such a species in Appendix II on this criterion should give due weight to management measures which have been implemented to reduce the exploitation rate, where it has been excessive for some years. If management measures have a reasonable likelihood of controlling harvesting, i.e. if violability is low or only moderate, then a listing on Appendix II may not be justified, On the other hand, if management has been ineffective at controlling the past excessive harvesting rate, provision 2aBi may be an important source of protection for highly vulnerable species with a history of overexploitation. Moreover, in those cases, criterion Annex 2aBi may provide some opportunity to use trade restrictions to aid in fisheries management before the species has reached a point where risk of extinction is unacceptably high. Such an approach provides national jurisdictions with a strong incentive to manage fisheries effectively, so they can document that past periods of over-harvesting, relative to sustainable rates, will not necessarily continue into the future,

With regard to criterion Annex 2aBii, the biological concerns are believed to have been treated fully in the discussion of the Annex 1 criteria. If the “small population” criterion (A) is applied in a way which is meaningful for marine fish and invertebrates, the guideline for what is a “small population” should take adequate account of threats presented by “other influences”. Specifically, it was noted that with regard to Annex 1 “small” should be interpreted relative to the particular life-history of the species of interest. Species whose life-histories, including the occurrence of migratory or breeding aggregations, made them particularly vulnerable, would require a generous interpretation of what constitutes a “small” population. Additionally, maintaining some acceptably low risk of extinction must ensure that the population is large enough not to be threatened by either demographic or environmental stochastic events, and these two categories should cover whatever “other influences” might be encountered. Therefore, it is unlikely that opportunities would be encountered often where criterion Annex 2aBii would be an appropriate tool to invoke for conservation of marine fish and invertebrates.

4.8 Criteria for Appendix II listing under Article II Paragraph 2b of CITES

This annex to the Fort Lauderdale criteria is commonly referred to as the "look-alike" provision.

4.8.1 Statement of Criterion

Species should be included in Appendix II in accordance with Article II, paragraph 2(b) , if they satisfy one of the following criteria.

A. The specimens resemble specimens of a species included in Appendix II under the provisions of Article II, paragraph 2(a) , or in Appendix I, such that a non-expert, with reasonable effort, is unlikely to be able to distinguish between them.

B. The species is a member of a taxon of which most of the species are included in Appendix II under the provisions of Article II, paragraph 2(a) , or in Appendix I, and the remaining species must be included to bring trade in specimens of the others under effective control.

4.8.2 Evaluation of Criterion

The problem posed for commercial fisheries by criterion Annex 2bA have been referred to several times in this report, particularly in Section 3, on tools for achieving conservation in marine ecosystems. The products of commercial fisheries are very commonly marketed in processed form, as fillets, fish sticks, surimi, or with heads, fins and internal organs removed. Such processing measures are often not cosmetic. Rather they are necessary to preserve product quality and marketability. However, in such forms the species, and in many cases even the genus or family of origin, of the product is impossible to identify without sophisticated and expensive biochemical testing. Stringent restrictions on trade in even a small number of marine fish producing whitefish fillets or frozen beheaded and de-finned tuna could disrupt commerce worth billions of dollars internationally, and devastate coastal economies in both developed and under-developed countries. Such consequences warrant serious thought before criteria with a high risk of yielding false alarms are used to assess the risk to commercially-exploited species.

The possibility that the look-alike provisions might be invoked would suggest that fisheries managers should:

- collectively be particularly careful that stocks did not decline to the state where an Appendix I listing was applicable, including ensuring appropriate capacity building for the proper management of affected species throughout their geographical range;
- individually consider the utility of joining or developing some scheme for certification of the origin of the fish products of concern to them, so as to minimize the disruption that listing of any species might bring to trade in other species.

The look-alike provisions could also be disruptive to the live aquarium trade, although the economic consequences would be of lesser magnitude and less widespread. Nonetheless, depending on the species being listed, the consequences could fall disproportionately on under-developed coastal states, where the aquarium trade is an important source of foreign trade. Similar situations have been encountered in the past, for example when the look-alike provision was invoked to protect species of orchids at risk of extinction. In that case, it was apparently concluded that conservation benefits outweighed the economic costs, and widespread requirements were implemented for permits and documentation to accompany orchids in international trade. The comparable trade-off of benefits and costs for aquarium trade in fish cannot be made without knowing which species of fish would be listed under Appendices I and II (Article II, paragraph 2a), and which species would be considered sufficiently similar to qualify for listing under this provision.

4.9 Issues regarding split-listing and higher taxa

Annex 3 to the resolutions agreed at the 9th meeting of the Conference of the Parties held in 1994 at Fort Lauderdale, USA (CITES 1994), is concerned with Special Cases. In general it urges avoiding complications in listing which create enforcement problems but allows some split listing if this is essential. The issue of split listings of a species is tied closely to how CITES and traditional fisheries management differ in their approach to conservation at the stock level vs. species level. Relevant considerations are discussed on Sections 3 and 7 of this Report. Recognition that because of the implementation difficulties, trade restrictions generally will work at the stock level only for a restricted set of marine species, primarily marine mammals and a few large circum-tropical pelagic species, should in no way be interpreted as de-emphasising the importance of conserving all fish stocks, and managing fisheries sustainably on a stock by stock basis.

4.10 Issues regarding precautionary measures

Annex 4 to the resolutions agreed at the 9th meeting of the Conference of the Parties held in 1994 at Fort Lauderdale, is concerned with the application of precautionary measures. Clause A of this is a general statement of the precautionary principle as applied to listings while clause B is specific to the revision of listings under Appendices I and II. The provisions of clause B are sensible and prudent rules that apply equally well to marine as to terrestrial species. Clause A might be advocated in aid of misguided attempts to list the non threatened target species of fisheries which take by-catches of endangered species. It is reiterated (see 4.2 above) that this interpretation would tend to undermine the basis and credibility of using trade regulations to address the direct contribution of trade to genuine conservation concerns.

4.11 Issues regarding definitions

Annex 5 to the resolutions agreed at the 9th meeting of the Conference of the Parties held in 1994 at Fort Lauderdale provides definitions. These are reviewed below.

Area of distribution: The definition in the Annex is generally agreeable. The suggested guideline for restricted area is discussed in section 4.4.3. For migratory aggregating species the definition would be more workable if it read "the smallest area essential for the survival of the species at its most dispersed or dis-aggregated stage". This is because some fish species form very dense schools or spawning aggregations, and evaluation of conservation status should not be based solely on this very limited area of distribution.

Decline: This definition has considerable implications for exploited aquatic species. These are discussed in section 4.5.3. Different indicators of decline (e.g. population counts, catch rates, total catch) may have different properties and result in different interpretations. These differences and their implications for conservation need to be examined in greater detail. Ideally, decline estimates would be based on population estimates. However, if population estimates are available, Criterion A should be used to evaluate status of the species. Therefore, this criterion would most likely be used with indices such as catch rate or total catch, and only when nothing else is known about the status of the species. The proposed rates appear appropriate bearing in mind that the 50% rate applies to Criterion C, whereas the 20% rate applies to Criterion A.

Extended period: This definition (used in Appendix II listing, section 4.7) leaves an appropriate degree of latitude for interpretation given the variety of life-histories that are found in fishes.

Fragmentation: The definition of fragmentation that is provided appears reasonable. However, given the wide variety of distribution patterns and life-histories exhibited by fishes, reasonable and flexible interpretation of the guideline will be critical in the use of fragmentation in Criterion B. See also Section 4.4.

Generation: This is a reasonable definition. As pointed out in section 2, generation time will normally decrease under exploitation. Therefore, the generation time for the lightly exploited population should be used.

Large fluctuations: Given that fluctuations are used in connection with other criteria (Criteria A and B), the definitions and guidelines provided here appear reasonable. However aquatic populations are notably highly variable, and some stocks (e.g. many small pelagics such as herring, sardine, and anchovy) can show both precipitous declines where cessation of harvest may do little to alter the decline, and explosive increases, sometimes after decades of depressed abundance. For some annual species, e.g. flyingfish, or species with drought resistant early life-history stages, the adult population may frequently decline to zero, and such information should receive full consideration in reviews of the status of species.

Population: This definition is discussed in section 4.3.

Possibly extinct: This definition appears reasonable.

Sub-populations: This definition is discussed in Section 4.4 and Section 5.

Threatened with extinction: This definition is considered to be reasonable.

4.12 Concordance of IUCN and CITES Criteria

Comparing the CITES listing criteria to listing criteria used by other conservation organisations could provide further insight into their completeness and practicality. Because they were revised at about the same time as the current CITES criteria were adopted, the criteria used for defining the IUCN red-book were thought to be especially suitable for such a comparison. These categories related to endangerment are: “critically endangered” (CR), “endangered” (EN) and “vulnerable” (VU). The “A” to “E” criteria used to categorise the species are:

A. declining population (past or projected)

B. small distribution and decline or fluctuation

C. small population size and decline

D. very small population and very restricted distribution

E. quantitative analysis (e.g. Population Viability Analysis)

Annex 2 of this document shows the IUCN criteria and the CITES (1994) Annex 1 criteria[4]. (CITES criteria and definitions can be found in full in subsections 4.3-4.4 above and in Annexes 3 to 5 of this report.) The three categories of endangered species adopted by IUCN, have criteria described by the same words but are distinguished by the number, rates and areas used to quantify the criteria. Hence, for clarity only their Vulnerable category is shown in Annex 2. Each CITES criterion is paired with its most comparable IUCN criterion.

[4] Where these are divided into sub-clauses under small Roman numbers, these are given Arabic order numbers, i.e. the third sub-clause of clause iv of criterion B is labelled Biv sub-clause 3

A general difference in approach is that the numbers used with the IUCN criteria are binding whereas those adopted by CITES are guidelines (not thresholds). As guidelines, the CITES criteria allow useful interpretation according to the life-history and circumstances of a species. However, whereas IUCN numbers refer to mature animals the CITES numbers refer to all individuals. For those marine species which produce abundant but high mortality larval stages, focusing on mature individuals will be more precautionary.

In general, the CITES criteria match the IUCN A-C criteria quite closely when the differences in interpretations above are taken into account. The match to criteria D is not close since IUCN regard critically small size or area as sufficient reason for categorisation whereas CITES set a higher number but does not accept this without other sub-clauses also being true. In practice it is difficult to imagine a species at low numbers at which one or other of the CITES sub-clauses would not apply. However, in further analyses to evaluate the degree to which CITES criterion A and B ensure a very low rate of misses, it is worth investigating if very low size or distribution area might be sufficient grounds for a listing. Very specialised analyses would be needed to establish if unqualified size criteria would add any greater protection to that offered by the existing criteria, and if so, what would be suitable sizes.

CITES also has no equivalent of the IUCN criterion E which is based upon quantitative analysis. Such an approach may be implied in CITES criteria clauses that do not map on to the IUCN criteria (see rows A3 and B4 of Annex 2) but some explicit criteria based upon scientifically sound analysis might be appropriate, following further analysis.

5 POPULATIONS AND SUBPOPULATIONS

One of the major areas of concern expressed by the FAO *Ad Hoc* Expert Group On Listing Criteria For Marine Species Under CITES was the focus of CITES listing on species (referred to by CITES as the population), in contrast to the normal focus of fisheries management on stocks (referred to by CITES as subpopulations). Thus, whereas CITES aims at ensuring that sufficient individuals of a species remain available on Earth, or in a geographical area, fisheries management in general aims at ensuring sustainability of <u>all</u> stocks.

Notwithstanding the common usage within CITES of the terms population and subpopulation as described above, Article 1 of the Convention states that *"species" means any species, subspecies, or geographically separate population thereof*. This appears to leave open the option for CITES to apply its criteria to subpopulations (or stocks) threatened with local extinction. The existence of Appendix III, where national jurisdictions may list a species of national concern and seek international cooperation in restricting trade in that species, without explicit consideration of the global status of the species, also may be argued to invite CITES action at the scale of stocks.

Given the extremely wide distribution and lack of data on the genetic structure of populations of certain species of marine fishes (e.g. highly migratory species) and mammals it is a general concern in fisheries research that a unit stock (= a CITES subpopulation), not identified as such, might be accidentally overfished. Circum-tropical large pelagic species such as yellowfin tuna, bigeye tuna, skipjack tuna, wahoo, and dolphinfish are examples of fishes where such situations could, in theory, occur. Marine mammal examples include bowhead whale, and walrus. Whether, as a consequence of overfishing, the subpopulation (or stock) could be extirpated with little or no possibility of natural recolonisation from other healthier

subpopulations from the same or neighbouring ocean basins is pure speculation with the present level of knowledge.

At the scale of a single ocean basin, one can consider shelf or coastal stocks that are distributed on both sides of the ocean, such as Atlantic cod and haddock, recolonisation might be slow, but possible, following extirpation of all stocks on one side of the ocean. Exchange among adjacent stocks around the ocean basin is documented regularly, however (Lilly *et al*. 1998, Taggert 1997), and this makes total extirpations of individual coastal stocks unlikely, unless stock distributions are disjunct, as with many anadromous species during spawning.

CITES listing of a species such as bigeye tuna in one ocean where it could be shown to be at risk of local extirpation could have extreme social and economic consequences for fisheries in other oceans where there was effective management and risk of local extirpation was low. An option for addressing the problem of local extirpation of a subpopulation would be to attempt to restrict trade in the catch from that subpopulation alone. Except at the largest geographical scales, implementation of this approach is likely to be so problematic as to render it ineffective. Even at the ocean basin scale, there is the potential for vessels to catch the species in one ocean and land it in another as catch from the subpopulation in the latter area. The voluntary listing of a species in Appendix III by a country or countries presents similar implementation problems. CITES acknowledges these potential difficulties, in stating under Annex 3 that *"Listing of a species in more than one Appendix should be avoided in general in view of the enforcement problems it creates ... Split listings that place some populations of a species in the Appendices and the rest outside the Appendices, should normally not be permitted"*.

The difficulty in implementing other than a global trade restriction, and the potential social and economic disruption for exploiters that have effective management in place, underscore that trade restrictions should be considered as a conservation measure of last resort. Except under exceptional circumstances, conservation of marine fishery resources would be best achieved through strengthening tools of national and international fisheries and ecosystem management.

6 FISHERIES BIOLOGICAL REFERENCE POINTS AND RISK OF EXTINCTION

Biological reference points, and their focal role in fisheries management, are discussed in Section 3.2. In well-monitored, large commercial fisheries, data are usually adequate to allow estimation of biological reference points in terms of biomass and exploitation rates, that can form the basis for sustainable exploitation of target fish or invertebrate stocks. As a result of the usually lower total value of landings in individual small-scale fisheries, they are less frequently well-monitored, but there are exceptions. Which reference points are used in specific cases varies with national jurisdiction, biological characteristics of the species being harvested, and history. Reference points may be set in terms of spawning biomass or fishing mortality associated with maximum sustainable yield, percentage of unexploited biomass, maximum recruits produced per spawner, possibility of collapse, or other currencies. However, in all cases the objective of reference points used in fisheries management is to maintain the stock in a highly productive state, and to keep the probability of collapse below commercially viable levels very low.

Unfortunately, not all fisheries are well-monitored, and even good monitoring programs may not record information on species taken as bycatch. Where fisheries are poorly monitored,

whether because of unclear or absent legal jurisdiction or simply inadequate resources for surveillance and management, data may be insufficient to estimate reference points based on sound biological models and information. In those cases, even if reference points have been estimated with the best scientific information available, there is less confidence that the reference points assure that management is intending to keep the stocks in highly productive states with low likelihood of collapse, and succeeding in doing so. Ideally, to be consistent with the precautionary approach, the reference points should be moderated to account for the additional uncertainty. However, this is not always done.

Population viability analysis is the current term for a family of analyses intended to estimate risk of extinction of species. PVA is described in Box 1. As noted in that Box, generally PVA becomes relevant when a population is so small that stochastic fluctuations in the population dynamics, population genetics, or environment conditions, cause noticeable fluctuations in estimated risk of extinction as well. Except for species of very high value, such population numbers are much lower than abundances at which stocks would be considered to be in a state of collapse, and hence far below any biological reference points used in managing commercial fisheries. Therefore, in most instances, risk of biological extinction would only become a relevant concern, with a greater than negligible likelihood of occurrence, long after all reference points used in fisheries management had been violated. The exceptions to this generalization are fisheries for species of exceptionally high value and vulnerability, and fisheries for species where the information available is so poor that only crude surrogates of biological reference points can be estimated to begin with. In those cases, special attention should be given to the sustainability of realized rates of exploitation, even when exploitation appears to comply with management targets.

7 KEY CONCERNS AND CONCLUSIONS

- Risk of extinction is a legitimate concern with regard to conservation of species of fish and aquatic invertebrates.
- The current flexibility of CITES criteria, when interpreted with their guidelines and definitions, are an important and positive feature. With a single major modification, the current criteria and guidelines have sufficient flexibility to allow a reasoned approach to individual proposals for listing, as long as the evaluation process is conducted in a scientifically sound and transparent way and takes into account the unique characteristics of each case.
- Because of the social, economic and human nutrition importance of commercial fisheries, listing of harvested marine species which in reality are false alarms can have very serious consequences.
- The guidelines for Criteria A and B should be interpreted generously with regard to the sizes of subpopulations and area of distribution necessary to ensure a low risk of extinction.
- Use of Criterion C, the decline criterion, alone, could lead to many false alarms, erroneously justifying the listing of many species at negligible risk of extinction.
- Criterion C should be used as a basis for listing an exploited marine or freshwater species only if data are insufficient to allow evaluation of that species with regard to Criteria A and B. However, when Criteria A or B are used to exempt a species which qualifies for listing on

the basis of Criterion C, the guidelines on numbers and/or area should be interpreted generously, so there is reasonable confidence that the population is neither small in numbers nor restricted in distribution.

- Because many fish products are landed in processed form, the "look-alike" provision should be used with sufficient circumspection in order to avoid chaos in commercial fisheries.
- CITES is most appropriate for protection of aquatic species which are of high economic value (**value**), vulnerable to over-exploitation due to life-history characteristics or ease of capture (**vulnerability**), and taken in fisheries where is it difficult to ensure compliance with management plans (**violability**).
- CITES should be viewed as a conservation tool of last resort, and conservation would usually be better served by strengthening capacity for fisheries and ecosystem management. In particular, effective fisheries and ecosystem management practice allows appropriate conservation actions to be taken long before a species is at risk of extinction.
- Species which are low in any of value, vulnerability, or violability are unlikely to require, or in other cases to benefit substantially from, listing under CITES.
- Risk of extinction among aquatic species is more related to life-history and ecological traits than to taxonomic affinities, although of course taxonomically related species are often similar in life-history and ecology.
- Tying criteria for evaluating risk of extinction too rigidly to taxonomic or to life-history traits runs the risk of compromising the present useful flexibility of CITES criteria, and could make matters worse rather then better.
- Review of the literature on extinctions, extirpations and classifications of risk of fish all suggest that habitat loss and degradation has been a much greater threat to survival of species than commercial harvesting, particularly for freshwater and coastal zone species. Notwithstanding, harvesting has been a major factor leading to dramatic decrease and extinctions of some cetaceans, pinnipeds and seabirds, including by small-scale fisheries on resources used for local consumption
- Particularly when they are estimated from good biological and fisheries data, biological reference points used as targets and limits in fisheries management are much higher than minimum safe population sizes likely to be estimated with population viability analysis.
- Fisheries management intends to ensure sustainability at the scale of individual stocks, whereas CITES is generally intended to act only to protect species. Very large implementation problems would be encountered if attempts were made to apply CITES action at the stock level. CITES guidelines on split-listings acknowledge these problems.

8 REFERENCES

Alverson, D.L., Freeberg, M.H., Murawski S.A. and Pope J.G. 1994. A global assessment of fisheries bycatch and discards. FAO Fish. Tech. Pap. 339: 233 pp.

Angermeier, P.L. 1995. Ecological attributes of extinction-prone species: loss of freshwater fishes of Virginia. Conservation Biol. 9:143-158.

Baillie, J., and B. Groombridge (ed.). 1996. IUCN Red List of threatened animals. IUCN Species Survival Commission, IUCN, Gland, Switzerland, and Cambridge, UK.

Baker, T.T. and 8 co-authors. 1996. Status of Pacific salmon and steelhead escapements in southeastern Alaska. Fisheries 21:6-18.

Balon, E.K. 1975. Reproductive guilds of fishes a proposal and definition. J. Fish Res. Board Can. 32:821-864.

Boehlert, G.W. 1996. Larval dispersal and survival in tropical reef fishes. Pp. 61-84, In: N.V.C. Polunin and C.M. Roberts [eds.]. Reef fisheries. Chapman and Hall, London.

Bradford, M.J. 1995. Comparative review of Pacific salmon survival rates. Can. J. Fish. Aquat. Sci. 52:

Bradford, MJ. 1998. Risk assessment for Thompson River coho salmon. Pacific Stock Assessment Review Committee Working Paper 98-18, 25p.

Brander, K. 1981. Disappearance of common skate *Raia batis* from Irish Sea. Nature 290: 48-49.

Breder, C.M. Jr. and D.E. Rosen. 1966. Modes of reproduction in fishes. Natural History Press, New York, 941 pp.

Bruton, M.N. 1995b. Threatened fishes of the world: *Latimeria chalumnae.* Environmental Biology of Fishes. 43:104.

Bruton, M.N. 1995. Have fishes had their chips? The dilemma of threatened fishes. Environmental Biology of Fishes 43: 1-27

Burgman, M.A., S. Ferson, and H.R. Akcakaya. 1993. Risk Assessment in Conservation Biology. Chapman and Hall. New York.

Caddy, J.F. and R. Mahon. 1995. Fishery Management Reference Points. FAO Fish Tech. Pap. No. 347: 87 p.

Cairns, M. and R.T. Lackey. 1992. Biodiversity and management of natural resources: the issues. Fisheries 17: 6-10.

Carlton, J. T. 1993. Neoextinctions in marine invertebrates. Am. Zool. 33: 499 - 507.

Carlton, J. T., G. J. Vermeij, D. R. Lindberg, D. A. Carlton, and E. C. Dudley. 1991. The first historical extinction of a marine invertebrate in an ocean basin: the demise of the eelgrass limpet *Lottia alveus*. Biol. Bull. 180: 72-80.

Casey, J. M. and R. A. Myers. 1998. Near extinction of a large, widely distributed fish. Science 281: 690-692.

Caughley, G. 1994. Directions in conservation biology. J. Anim. Ecol. 63: 215-244.

CITES, 1994. Convention On International Trade In Endangered Species Of Wild Fauna And Flora, Ninth Meeting of the Conference of the Parties Fort Lauderdale (United States of America), 7 to 18 November 1994. Conference of the parties resolution Conf. 9.24

Cochrane, K.L., D.S. Butterworth, J.A.A. de Oliveira and B.A. Roel. 1998. Management procedures in a fishery based on highly variable stocks and with conflicting objectives: experiences in the South African pelagic fishery. Rev.Fish Biol.Fish. 8, 177-214.

Courchamp, F., T. Clutton-Brock, and B. Grenfell. 1999. Inverse density dependence and the Allee effect. Trends in Ecology and Evolution. 14: 405-410.

Diamond, J.M. 1987. Extant unless proven extinct? Or extinct unless proven extant? Conservation Biology 1: 77-79.

Dickson, R.R., J Lazier, J. Meinke, P., Rhines, and J. Swift. 1998. Long term coordinated changes in convective activity of the North Atlantic. Progress in Oceanography 36: 241-295.

DFO. 1999. Stock Status Report for Northern Cod. CSAS SSR 98-A01.

Emlen, J.M. 1992. Ecology: An Evolutionary Perspective. 3rd Edition. Academic Press.

FAO. 1996a. Precautionary approach to capture fisheries and species introductions. FAO Technical Guidelines for Responsible Fisheries 2, 54 p.

FAO. 1996b. Fishing operations. FAO Technical Guidelines for Responsible Fisheries 1, 86 p.

FAO. 1998. Report of the meeting of the FAO *Ad Hoc* Expert Group On Listing Criteria For Marine Species Under CITES, Cape Town, South Africa, 20 November 1998. COFI/99/Inf.16 Part II. 11 pp.

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

Ferson, S. and M.A. Burgman. 1995. Correlations, dependency bounds and extinction risks. Biological Conservation. 73: 101-105.

Francis, R.C., S.R. Hare, A.B. Hollowed, and W.S. Wooster. 1998. Effects of interdecadal climate variability on the oceanic ecosystems of the Northeast Pacific. Fisheries Oceanography 7: 1-21.

Garcia, S.M. and C. Newton. 1997. Current situation, trends and prospects in world capture fisheries. Pp. 3-27 In: E.K. Pikitch, D.D. Huppert, and M.P. Sissenwine [eds.]. Global trends: fisheries management. American Fisheries Society Symposium 20, Bethesda, Maryland.

Gilpin, M.E. 1990. Extinction of finite metapopulations in correlated environments. In S. Shoorocks, ed. Life in a Patchy Environment. Oxford University Press.

Groom, M.J. and M.A. Pascual. 1998. The analysis of population persistence: An outlook on the practice of viability analysis. pp 6-28 in P.L. Fiedler and P.M. Karieva, eds. Conservation Biology for the Coming Decade. Chapman and Hall, New York.

Hudson, E.J., Baillie, J., Hall, H., Mace, G.M., Punt, A., Roberts, C., Sadovy, Y., Safina, C., Sobel, J., and A. Vincent 1997. Applying the ICUN Red List Criteria to Marine Fish: a summary of initial guidelines. Species (June 1997) p.18-19.

Hughes, R.M. and R.F.Noss. 1992. Biological Diversity and Biological Integrity: Current Concerns for Lakes and Streams. Fisheries 17:11-19.

ICCAT. 1999. Report for the biennial period, 1998-99. Part 1 (1998) – Vol. 2. International Commission for the Conservation of Atlantic Tunas, Madrid, 289 pp.

ICES. 1998. Report of the Study Group on Implementation of the Precautionary Approach. ICES CM:1998/ACFM 1.

Isaac, N. and G.M. Mace. 1998. The IUCN Criteria Review: report of scoping workshop. IUCN Species Survival Commission, Gland, Switzerland. 34+pp.

IUCN. 1996. 1996 IUCN Red List of Threatened Animals. IUCN, Gland, Switzerland. 386 pp + Intro pp + Annexes. (also cited as Baillie and Groombridge 1996).

Jennings, S., S.P.R. Greenstreet, and J.D. Reynolds. 1999. Structural change in an exploited fish community : a consequence of differential fishing effects on species with contrasting life-histories. J. Anim. Ecol. 68 : 617-627.

Jennings, S., J.D. Reynolds and S. C. Mills. 1998. Life-history correlates of responses to fisheries exploitation. Proc. R. Soc. Lond. B, 265 : 333-339.

Johannes, R.E. 1997. Grouper spawning aggregations need protection. SPC Live Reef Fish Information Bulletin #3 – December 1997: 13-14.

Jonsson, B., R.S. Waples, and K.D. Friedland. 1999. Extinction considerations for diadromous fishes. ICES Journal of Marine Science 56: 405-409

Koslow, J.A., Hanley, F. and Wicklund, R. 1988. Effects of fishing on reef fish communities at Pedro Bank and Port Royal Cays, Jamaica. Marine Ecology Progress Series, 43: 201-212.

Leidy, R.A. and P.B. Moyle. 1998. Conservation status of the world's fish fauna: An overview. pp 187-227. in P.L. Fiedler and P.M. Karieva, eds. Conservation Biology for the Coming Decade. Chapman and Hall, New York.

Lierman, M. and R. Hilborn. 1997. Depensation in fish stocks: a hierarchic Bayesian meta-analysis. Canadian Journal of Fisheries and Aquatic Sciences. 54: 1976-1984.

Lilly, G.R. and 6 co-authors. 1998. An assessment of the cod stock in NAFO Div. 2J+3KL. NAFO Sci. Council Research Document 98. 94 pp.

Mace, G.M. 1999. Ed. The IUCN Criteria Review: Report of the marine workshop. Tokyo, Japan, January 16th-17th, 1999.

Mace, P.M. 1994. Relationships between common biological reference points used as thresholds and targets of fisheries management strategies. Can. J. Fish. Aquat. Sci. 51: 110-122.

Malakoff, D. 1997. Extinction on the high seas. Science 277: 486 - 488.

McDowall, R. M. 1999. Different kinds of anadromy : different kinds of conservation problems. ICES Journal of Marine Science. 56:410-413.

McKinney, M. L. 1997. Extinction vulnerability and selectivity: combining ecological and paleontological views. Ann.Rev.Ecol.Syst. 28: 495-516.

Miller, R. R., J. D. Williams and J. E. Williams. 1989. Extinctions of North American fishes during the past century. Fisheries (Am. Fish. Soc.) 14 (6): 22-38.

Miller, R.R. and E.P. Pister. 1971. Management of the Owens pupfish, *Cyprinodon radiosus*, in Mono County, California. Transactions of the American Fisheries Society. 100:502-509.

Moyle, P.B. and R.A. Leidy 1992. Loss of biodiversity in aquatic ecosystems: evidence from fish fauna. pp. 127-169 in P.L. Fiedler and S.K. Jain, eds. Conservation biology: the theory and practice of nature conservation, preservation, and management. Chapman and Hall. New York.

Musick, J. A. 1998. Endangered marine fishes: criteria and identification of North American stocks at risk. Fisheries, (Bethesda) 23 (2): 28-30.

Nehlsen, W., J.E. Williams and J.A. Lichatowich. 1991. Pacific salmon and the crossroads: stocks at risk from California, Oregon, Idaho and Washington. Fisheries 16(2):4-21.

Ogutu-Ohwayo, R., R.E. Hecky, A.S. Cohen, and L. Kaufman. 1997. Human impacts on the African Great Lakes. Environmental Biology of Fishes 50: 117-131.

Pajaro, M.G. and A.C.J. Vincent. 1996. Seahorse conservation in the central Philippines: a community based approach. Sea Wind 10(4): 7-12.

Parent, S. and L. M. Schrimi. 1995. A model for the determination of fish species at risk based upon life-history traits and ecological data. Can. J. Fish. Aquat. Sci. 52: 1768 - 1781.

Powles, H.P. and 8 co-authors. in press. DFO Risk of Extinction Working Group Report. Canadian Technical Report in Fisheries and Aquatic Science. 70 pp.

Reaka-Kudla, M.L. 1997. The global biodiversity of coral reefs: a comparison with rain forests. pp. 83-108 in M.L. Reaka-Kudla, D.E. Wilson, and E.O. Wilson, eds. Biodiversity II: Understanding and Protecting our Biological Resources. Joseph Henry Press, Boston.

Roberts, C. M. and J. P. Hawkins.1999. Extinction risk in the sea. Trends in Ecology and Evolution 14 (6): 241-246.

Ruckleshaus, M. and C.G. Hays. 1998. Conservation and management of species in the sea. pp. 112-155 in P.L. Fiedler and P.M. Karieva, eds. Conservation Biology for the Coming Decade. Chapman and Hall, New York.

Sadovy, Y. 1997. Live reef-fishery species feature prominently in first marine fish IUCN Red List. SPC Live Reef Fish Information Bulletin #2 – May 1997: 13-14.

Sinclair, A., D. Gascon, R. O'Boyle, D. Rivard, and S. Gavaris. 1991. Consistency of some northwest Atlantic groundfish stock assessments. NAFO Scientific Council Studies, 16:59-77.

Slaney, T. L., K. D. Hyatt, T. G. Northcote and R. J. Fielden. 1996. Status of anadromous salmon and trout in British Columbia and Yukon. Fisheries 21(10):20-35.

Stephens, P.A. and W.J. Sutherland. 1999. Consequences of the Allee effect for behaviour, ecology and conservation. Trends in Ecology and Evolution, 14: 401-405.

Taggert, C.T. 1997. Bank scale migration patterns in cod. NAFO Scientific Council Studies 29: 51-60.

Taylor, D.W. 1991. Freshwater molluscs of California: a distributional checklist. Calif. Fish Game 67:140-163.

Taylor, F.R., R.R. Miller, J.W. Pedretti and J.E. Deacon.1988. Rediscovery of the Shoshone pupfish *Cyprinodon nevadensis shoshone* (Cyprinodontidae), at Shoshone Springs, Inyo County, California. Bulletin of the Southern California Academy of Sciences 87:67-73.

Tuljapurkar, S. 1990. Population Dynamics in Variable Environments. Lecture Notes in Biomathematics 85. Springer-Verlag, New York.

United Nations. 1983. The Law of the Sea. Official text of the United Nations Convention on the Law of the Sea with Annexes and Table: United Nations, New York, 224 pp.

United Nations. 1992. Agenda 21: Programme of action for sustainable development. Final text of agreements negotiated by governments at the United Nations Conference on Sustainable Development (UNCED), 3-4 June 1992, Rio de Janeiro, Brazil, 294 pp.

United Nations. 1995. 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.

Upton, H. 1992. Biodiversity and conservation of the marine environment. Fisheries 17:20-25.

Witte, F., T. Goldschmidt, J. Wanick, M. vanOijen, K. Goudswaard, E. Witte-Maas, and N. Bouton. 1992. The destruction of an endemic species flock: quantitative data on the decline of the haplochrome cichlids of Lake Victoria. Environmental Biology of Fishes 34:1-28.

Yablokov, A.V. and S.A. Ostroumov. 199?. Conservation of living nature and resources: problems, trends and prospects. Springer Verlag, New York.

Annex 1: A summary by class, order and family of the species listed on the 1996 IUCN red list by category

(EX = extinct, EW = extinct in the wild, CR = critically endangered, EN = endangered, VU = vulnerable, LR = lower risk, DD = data deficient)

Order	Family	Not marine							Marine						
		EX	EW	CR	EN	VU	LR	DD	EX	EW	CR	EN	VU	LR	DD
Elasmobranchii															
Carchariniformes	Carcharhinidae			1										3	
Hexanchiformes	Hexanchidae													1	
Lamniformes	Cetorhinidae												1		
	Lamnidae												1	1	
	Odontaspididae												1		
Myliobatiformes	Dasyatidae					1									
Orectolobiformes	Rhincodontidae														1
Pristiformes	Pristidae										1	3			
Rajiformes	Rajidae														1
Squaliformes	Squalidae													1	
Actinopterygii															
Acipenseriformes	Acipenseridae			5	8	8			2		2	16	5	3	
	Polyodontidae			1		1									
Atheriniformes	Atherinidae	1		6	5	30	8	28							
	Phallostethidae					1									
Batrachoidiformes	Batrachoididae												5		
Beloniformes	Adrianichthyidae			2	3	5									
	Hemiramphidae					3	1	2							
Characiformes	Characidae				1	1		6							
Clupeiformes	Clupeidae				2	2		7					1		
	Engraulidae							1							
Cypriniformes	Balitoridae				1	16	1	8							
	Catostomidae	2		1	4	8	3	2							
	Cobitidae			1	1	2	4	11							
	Cyprinidae	15	1	41	31	89	31	49							
Cyprinodontiformes	Aplocheilidae				1	8		1							
	Cyprinodontidae	6	3	10	14	7	1	5							
	Goodeidae	1	2	4	3	3									
	Poeciliidae	3		4	2	8	2	5							
Gadiformes	Gadidae												2		
	Moridae										1				
Gasterosteiformes	Gasterosteidae			1											
	Pegasidae												4		4
Lophiiformes	Brachionichthyidae										1				
Ophidiiformes	Bythitidae					6		1					1		
Osteoglossiformes	Notopteridae						1								
	Osteoglossidae				1		1	1							
Perciformes	Ambassidae							3							

Order	Family	Not marine							Marine						
		EX	EW	CR	EN	VU	LR	DD	EX	EW	CR	EN	VU	LR	DD
	Anabantidae				1										
	Belontiidae			3	2	7	2								
	Blenniidae														1
	Callionymidae										1				
	Centrarchidae					1	1	1							
	Centrolophidae					1		2							
	Chaenopsidae					1							1		
	Chaetodontidae												5		
	Cichlidae	44	5	39	13	36	1	1							
	Clinidae				1										
	Elassomatidae					1	1								
	Eleotridae					8	8	5							
	Gobiidae			5		18	12	21						1	1
	Haemulidae											1			
	Labridae												4		
	Lutjanidae												2		
	Mugilidae				1										
	Percichthyidae			1	3	2		5							
	Percidae	1		2	4	27	10	4							
	Polyprionidae										1				
	Pomacanthidae												1		
	Pomacentridae												3		
	Pseudochromidae												1		
	Scaridae												1		
	Sciaenidae			1											
	Scombridae										3	3	2		2
	Serranidae										3	1	13	2	2
	Sparidae						1					1			
	Terapontidae					3	6	5							
	Xiphiidae											1			1
Percopsiformes	Amblyopsidae			1		3									
Pleuronectiformes	Pleuronectidae											1	1		
Salmoniformes	Galaxiidae			4		9	4	6							
	Lepidogalaxiidae						1								
	Osmeridae				1			2							
	Plecoglossidae				1										
	Retropinnidae	1				1									
	Salangidae					1									
	Salmonidae	4		4	6	10		14							
	Umbridae					1	1								
Scorpaeniformes	Cottidae	1		2		4		2							
	Scorpaenidae										1	1	1		
Siluriformes	Amblycipitidae				1										
	Ariidae							5				1			
	Bagridae			1	1	2		2							

Order	Family	Not marine							Marine						
		EX	EW	CR	EN	VU	LR	DD	EX	EW	CR	EN	VU	LR	DD
	Clariidae			4		4									
	Diplomystidae				1			2							
	Heteropneustidae					1									
	Ictaluridae			2	1	10	2	3							
	Mochokidae			1											
	Pangasiidae				1			1							
	Pimelodidae					2		2							
	Plotosidae					1									
	Siluridae				1			2							
	Sisoridae					1									
	Trichomycteridae	1				1	2	7							
Synbranchiformes	Mastacembelidae							1							
	Synbranchidae				1			3							
Syngnathiformes	Syngnathidae			1				4					36		7
Tetraodontiformes	Balistidae												1		
	Tetraodontidae												2		5
Total		80	11	148	117	355	105	230	2	0	14	29	95	12	25

Annex 2: Concordance of CITES and IUCN listing criteria

IUCN Criteria	IUCN Category 'Vulnerable'	CITES 1994 Annexes 1-5	Comment
A. Declining population Population decline rate at least using either 1 or 2	20% in 10 years or 3 generations	Guideline 50% in 5 years or 2 generations 20% in 10 years or 3 generations for small wild populations Use 1-3	IUCN specifies mature individuals. CITES does not
1. Population reduction observed, estimated, inferred, or suspected in the past or,		Ci but add (but with a potential to resume)	Could lead to inappropriate listings
2. Population decline projected or suspected in future based on:			
a. direct observation		-	How?
b. an index of abundance appropriate for the taxon		-	How?
c. a decline in area of occupancy, extent of occurrence and/or quality of habitat		Cii sub-clause 1	
d. actual or potential levels of exploitation		Cii sub-clause 2	
e. the effects of introduced taxa, hybridisation, pathogens, pollutants, competitors, or parasites		Cii sub-clause 3	
3. In CITES but not used by IUCN	-----	Cii sub-clause 4	Decreased reproductive potential
B. Small Distribution and Decline or Fluctuation Either extent of occurrence or area or occupancy and 2 of the following 3:	< 20,000 km^2 < 2,000 km^2	Area of distribution Guideline 10,000 km^2 and one of 1-4	CITES takes a narrow definition of area guideline to be interpreted by species
1. Either severely fragmented: (isolated sub-populations with a reduced probability of re-colonisation, if once extinct) or known to exist at a number of locations	≤ 10	Bi	CITES guideline 500km^2 or less for each sub-populations
2. Continuing decline in any of the following:	any rate		CITES specifies an observed, inferred or projected decline. The decline rate is as in A above.
a. extent of occurrence		Biv sub-clause 1	
b. area of occupancy		Biv sub-clause 1	
c. area, extent and/or quality of		Biv sub-clause 4	

IUCN Criteria	IUCN Category 'Vulnerable'	CITES 1994 Annexes 1-5	Comment
habitat d. number of locations or subpopulations e. number of mature individuals		Biv sub-clause 2 -	
3. Fluctuating in any of the following: a. extent of occurrence b. area of occupancy c. number of locations or subpopulations d. number of mature individuals	> 1 order/mag.	1 order of magnitude in 2 years or less Bii (area of distrib.) " Bii (number of sub-pop.) -	
4. In CITES not mentioned in IUCN criteria	----	Biv sub-clause 3 (decline in individuals). Biv sub-clause 5 (decline in reproductive potential). Biii (high vulnerability due to biology or behaviour).	
C. Small population size and decline Number of mature individuals and 1 of the following 2:	< 10,000	<5,000 and one of the following	
1. rapid decline rate	10% in 10 years or 3 generations	See rates above Ai	
2. continuing decline and either: a. fragmented; or b. all individuals in a single subpopulation	any rate all subpops ≤1000	Aii, no decline needed Aiii, no decline needed	CITES small sub pop.
D. Very Small or Restricted, either:			
1. number of mature individuals; or	< 1,000	Guideline <5,000 and one of Ai - Av	CITES. Low numbers not sufficient alone.
2. population is susceptible.	area of occupancy <100km^2 or number of locations <5	Guideline <10 000km^2 and one of Bi - Biv	CITES. Low area not sufficient alone
E. Quantitative Analysis, indicating probability of extinction in the wild to be at least	10% in 100 years	No CITES equivalent.	

Annex 3: Biological criteria for listing species in CITES Appendix I (as provided in CITES COP 9.21, 1994, Annex 1)

Biological Criteria for Appendix I

The following criteria must be read in conjunction with the definitions, notes and guidelines listed in Annex 5.

A species is considered to be threatened with extinction if it meets, or is likely to meet, **at least one** of the following criteria.

A. The wild population is small, and is characterized by **at least one** of the following:

i) an observed, inferred or projected decline in the number of individuals or the area and quality of habitat; or

ii) each sub-population being very small; or

iii) a majority of individuals, during one or more life-history phases, being concentrated in one sub-population; or

iv) large short-term fluctuations in the number of individuals; or

v) a high vulnerability due to the species' biology or behaviour (including migration) .

B. The wild population has a restricted area of distribution and is characterized by **at least one** of the following:

i) fragmentation or occurrence at very few locations; or

ii) large fluctuations in the area of distribution or the number of sub-populations; or

iii) a high vulnerability due to the species' biology or behaviour (including migration) ; or

iv) an observed, inferred or projected decrease in any one of the following:

- the area of distribution; or

-the number of sub-populations; or

-the number of individuals; or

-the area or quality of habitat; or

-reproductive potential.

C. A decline in the number of individuals in the wild, which has been **either**:

i) observed as ongoing or as having occurred in the past (but with a potential to resume); or

ii) inferred or projected on the basis of any one of the following:

- a decrease in area or quality of habitat; or
- levels or patterns of exploitation; or
- threats from extrinsic factors such as the effects of pathogens, competitors, parasites, predators, hybridization, introduced species and the effects of toxins and pollutants; or
- decreasing reproductive potential.

D. The status of the species is such that if the species is not included in Appendix I, it is likely to satisfy one or more of the above criteria within a period of five years.

Annex 4: Suggestions for rewording of biological criteria for listing species in CITES Appendix I

General

Changes in wording from the existing criteria are shown underlined.

Re-Statement of Introductory Text to Annex 1

Annex 1

BIOLOGICAL CRITERIA FOR APPENDIX 1

The following criteria must be read in conjunction with the definitions, notes and guidelines listed in Annex 5.

A species can be considered to be threatened with extinction if it meets, or is likely to meet, **either** of Criterion A **or** Criterion B. Additionally, a species is considered to be threatened with extinction if it meets, or is likely meet Criterion C **and if and only if** data are considered inadequate[♠] to evaluate the status of the species relative to **both** Criteria A and B.

Re-Statement of Criterion A

The wild population is small[#] (guideline {not threshold} <5000), and is characterized by ***at least one*** of the following:

i) an observed, inferred, or projected decline in the number of individuals or the area and quality of habitat; or

ii) each sub-population being very small (guideline {not threshold}, the largest sub-population[#] is < than 2000); or

iii) a majority of individuals, during one or more life-history phases, being concentrated in one sub-population; or

iv) large short-term fluctuations in the number of individuals; or

v) a high vulnerability due to the species' biology or behavior (including migration).

Comment:.

We had substantial interest in specifying a population size sufficiently small that it, alone, would justify listing a species, regardless of evidence of information relative to sub-clauses. Lacking quantitative analysis to justify any specific lower value, we do not propose an arbitrary "very small" value, but do stress that the guideline should be interpreted generously, and careful consideration be given to species which may be highly vulnerable due to Aiii) or Av).

Re-Statement of Criterion B

The wild population has a very restricted area of distribution (guideline {not threshold}, <10,000km^2) and is characterised by **at least one** of the following:

i) fragmentation or occurrence at very few locations; or

ii) large fluctuations in the area of distribution or the number of sub-populations; or

iii) a high vulnerability due to the species' biology or behaviour (including migration); or

iv) an observed, inferred or projected decrease in any of the following:

-the area of distribution; or

[♠] Based upon an appropriately reviewed scientific process.

[#] mature individuals, and value taken as 5% lower confidence interval

-the number of sub-populations; or

-the number of individuals; or

-the area or quality of habitat; or

-reproductive potential.

Comment:

The same concerns as expressed in the Comment under Criterion A apply to Criterion B, and we encourage careful consideration be given when a species may be highly vulnerable with regard to Bi) or Biii).

Re-Statement of Criterion C

A decline in the number of individuals in the wild, which has been **either**:

i) observed as ongoing or as having occurred in the past (but with a potential to resume); or

ii) inferred or projected on the basis of any of the following:

-a decrease in area or quality of habitat; or

-levels or patterns of exploitation; or

-threats from extrinsic factors such as the effects of pathogens, competitors, parasites, predators, hybridization, introduced species and the effects of toxins and pollutants; or

-decreasing reproductive potential."

Future additional criterion new D

In our contrasting of the IUCN and CITES criteria, it was apparent that there could be value to an additional criterion, based on appropriate quantitative analysis of the population trajectory of the exploited species. Details of such a criterion would require careful development, in view of the diversity of modeling approaches used to describe fish population dynamics. However a criterion of the nature that:

> "If an appropriate quantitative analysis of the species' population dynamics indicated the probability of extinction to be at least x% in y years[5], then notice would be given of intention to list the species after the interval of (fewer than y) years had elapsed. This intention to list could be reviewed at any time during the interval, should interested parties provide evidence that the decline had been either brought under control, or had accelerated."

would have several benefits. It would provide a clear incentive for management authorities to take effective action to stem over-harvesting *before* a species was reduced to population size with an unacceptably high risk of extinction. It would also provide an incentive to harvesting nations to comply with management actions and provide data, in order to ensure there was evidence that the decline had ceased, and consequently be allowed continued opportunity for trade in the species. Finally, it would allow rapid re-evaluation if there were indications that harvesting had accelerated to "beat the ban", ensuring more rapid listing if harvesters were irresponsible.

However, we note that the current provisions of Criterion D, applied to Subarticle Ai) are likely adequate to allow results of sound population models to be used as a basis for listing under Appendix II.

Re-Statement of other Criteria

No change is proposed to criteria old D or to the trade criteria or to Annex 3.

---

[5] where x and y would be relevant to the species of concern, and assure a desired degree of risk aversion. Determining how to estimate appropriate values for x and y is one of the tasks which must be explored thoroughly before such a criterion is adopted.

Annex 5: Definitions, notes and guidelines as provided in CITES COP 9.21, 1994, Annex 5

Definitions, Notes and Guidelines

Area of distribution

Area of distribution is defined as the area contained within the shortest continuous imaginary boundary which can be drawn to encompass all the known, inferred or projected sites of occurrence, excluding cases of vagrancy (though inferring and projecting area of occurrence should be undertaken carefully, and in a precautionary manner) . The area within the imaginary boundary should, however, exclude significant areas where the species does not occur, and so in defining area of distribution, account should be taken of discontinuities or disjunctions in the spatial distribution of species. For migratory species, the area of distribution is the smallest area essential at any stage for the survival of that species (e.g. colonial nesting sites, feeding sites for migratory taxa, etc.). For some species in trade where data exist to make an estimate, a figure of less than 10,000 km^2 has been found to be an appropriate guideline (not a threshold) of what constitutes a restricted area of distribution. However, this figure is presented only as an example, since it is impossible to give numerical values that are applicable to all taxa. There will be many cases where this numerical guideline does not apply.

Decline

A decline is a reduction in the number of individuals, or a decrease of the area of distribution, the causes of which are either not known or not adequately controlled. It need not necessarily still be continuing. Natural fluctuations will not normally count as part of a decline, but an observed decline should not be considered part of a natural fluctuation unless there is evidence for this. A decline that is the result of a harvesting programme that reduces the population to a planned level, not detrimental to the survival of the species, is not covered by the term "decline". For some species in trade where data exist to make an estimate, a decrease of 50% or more in total within 5 years or two generations, whichever is the longer, has been found to be an appropriate guideline (not a threshold) of what constitutes a decline. A guideline (not a threshold) of what constitutes a decline in a small wild population could be 20% or more in total within ten years or three generations, whichever is the longer. However, both these figures are presented only as examples, since it is impossible to give numerical values that are applicable to all taxa. There will be many cases where these numerical guidelines do not apply.

Extended period

The meaning of the term extended period will vary according to the biological characteristics of the species. Selection of the period will depend upon the observed pattern of natural fluctuations in the abundance of the species and on whether the number of specimens removed from the wild is consistent with a sustainable harvesting programme that is based on these natural fluctuations.

Fragmentation

Fragmentation refers to the case where most individuals within a taxon are found in small and relatively isolated sub-populations, which increases the probability that these small sub-populations will become extinct and the opportunities for re-establishment are limited. For some species in trade where data exist to make an estimate, an area of distribution of 500 km^2 or less for each subpopulation has been found to be an appropriate guideline (not a threshold) of what constitutes fragmentation. However, this figure is presented only as an example, since it is impossible to give numerical values that are applicable to all taxa. There will be many cases where this numerical guideline does not apply.

Generation

Generation is measured as the average age of parents in the population; except in the case of species that breed only once a lifetime, this will always be longer than the age at maturity.

Large fluctuations

Large fluctuations occur in a number of species where the population size or area of distribution varies widely, rapidly and frequently, with a variation greater than one order of magnitude. For some species in trade where data exist to make an estimate, a figure of two years or less has been found to be an appropriate guideline (not a threshold) of what constitutes a short-term fluctuation. However, this figure is presented only as an example, since it is impossible to give numerical values that are applicable to all taxa. There will be many cases where this numerical guideline does not apply.

Population

Population is measured as the total number of individuals of the species (as defined in Article I of the Convention) . In the case of species biologically dependent on other species for all or part of their life cycles, biologically appropriate values for the host species should be chosen. For some species in trade where data exist to make an estimate, a figure of less than 5,000 individuals has been found to be an appropriate guideline (not a threshold) of what constitutes a small wild population. However, this figure is presented only as an example, since it is impossible to give numerical values that are applicable to all taxa. There will be many cases where this numerical guideline does not apply.

Possibly extinct

A species is presumed extinct when exhaustive surveys in known and/or suspected habitat, and at appropriate times (diurnal, seasonal, annual) , throughout its historic range have failed to record an individual. Before a species can be declared possibly extinct, surveys should take place over a time frame appropriate to the species' life cycle and life form.

Sub-populations

Sub-populations are defined as geographically or otherwise distinct groups in the population between which there is little exchange. For some species in trade where data exist to make an estimate, a figure of less than 500 individuals has been found to be an appropriate guideline (not a threshold) of what constitutes a very small sub-population. However, this figure

is presented only as an example, since it is impossible to give numerical values that are applicable to all taxa. There will be many cases where this numerical guideline does not apply.

Threatened with extinction

Threatened with extinction is defined by Annex 1. The vulnerability of a species to threats of extinction depends on its population demographics, biological characteristics, such as body size, trophic level, life cycle, breeding structure or social structure requirements for successful reproduction, and vulnerability due to aggregating habits, natural fluctuations in population size (dimensions of time and magnitude), residency/migratory patterns. This makes it impossible to give numerical values for population size or area of distribution that are applicable to all taxa.

Annex 6: Glossary

Anadromous	Fish that spend their adult life in the sea but swim upriver to freshwater spawning grounds in order to reproduce. Opp.= Catadromous
Benthic	A benthic organism is one attached or resting on the bottom or living on the bottom sediments.
Biodiversity	The variety and variability among living organisms from all sources including, inter alia, terrestrial, marine and other aquatic ecosystems and the ecological complexes of which they are part; this includes diversity within species, between species and of ecosystems. Diversity indices are measures of richness (the number of species in a system); and to some extent, evenness (variances of species' local abundance). They are therefore indifferent to species substitutions which may, however, reflect ecosystem stresses (such as those due to high fishing intensity).
Biological reference points	A biological reference point indicates a particular (biological) state of a fishery resource indicator corresponding to a situation considered as desirable (Target reference point, TRP) or undesirable and requiring immediate action (Limit reference point, LRP, and Threshold reference point, ThRP)
Bycatch	Species taken in a fishery targeting on other species or on a different size range of the same species. That part of the bycatch which has no human value is discarded and returned to the sea, usually dead or dying
Demographic stochasticity	The natural variability (or randomness or probabilistic nature) of the demographic processes (e.g. a small subpopulation only producing male offspring and hence dying out).
Density dependence	The dependence of reproductive pattern and functions on population density *(WWW Webster Dictionary).*
Depensation	The phenomenon whereby as a population declines, it will reach a point where the mortality rate, for example caused by predation, will be greater than the production rate of the population. One it reaches this point, unless circumstances change, the population will continue to decline until extinct.
Diadromous	Particularity of a fish which migrates between salt and fresh waters *(WWW Webster Dictionary).*
Endemic	Species restricted to a specified region or locality.
Environmental stochasticity	The natural variability (or randomness or probabilistic nature) of environmental processes.
Estuarine	Relating to, or formed in, an estuary (e.g. estuarine currents; estuarine animals) *(WWW Webster Dictionary).* Belonging to an estuary (river mouth), an area in which sea water is appreciably diluted by fresh water from rivers.
Exploitation rate	Applied on a fish stock, it is the proportion of the numbers or biomass removed by fishing. A 10% exploitation rate means that 10% of the available stock is being harvested within the time frame considered (per year, per month, etc.). As a measure of fishing pressure, it is proportional to fishing mortality
Extinct	No longer existing (i.e. an extinct animal) *(WWW Webster Dictionary)*
Extirpate	To destroy completely (e.g. wipe out); to exterminate *(WWW Webster Dictionary)*
Fecundity	In general, the potential reproductive capacity of an organism or population expressed in the number of eggs (or offspring) produced during each reproductive cycle. Fecundity usually increases with age.

Fishing mortality	A mathematical expression of the rate of deaths of fish due to fishing. Fishing mortality is often expressed as a rate that indicates the percentage of the population caught in a year; e.g. a fishing mortality rate of 0.2 implies that approximately 20% of the average population will be removed in a year due to fishing.
Fragmentation	Of populations or ranges:
Intrinsic rate of increase	The proportional rate of increase of a population at very low population numbers or biomass where density dependent effects are negligible. It therefore represents the average maximum proportional growth rate of the population.
Lek (breeding system)	An assembly area where animals carry on display and courtship behavior *(WWW Webster Dictionary).*
Leslie / Lefkowitz matrices	A matrix which includes the fecundity and survival rates per uniform (Leslie) or variable (Lefkowitz) age class of a population, allowing the projection of population numbers by age class over time.
Ontogeny	The development or course of development especially of an individual organism *(WWW Webster Dictionary).* The succession of life stages
Population Viability Analysis	PVA: The current term for a family of analyses intended to estimate risk of extinction of species. A term applied to a range of population analysis modeling approaches, which have in common that stochastic population trajectories are projected into the future, based on present knowledge of mortality and fecundity schedules, and scenarios about possible future conditions (Groom and Pascal 1998).
Productivity	Relates to the birth, growth and death rates of a stock. A highly productive stock is characterized by high birth, growth and mortality rates, and as a consequence, a high turn-over and production to biomass ratios (P/B). Such stocks can usually sustain higher exploitation rates and, if depleted, could recover more rapidly than comparatively less productive stocks.
Resilient	For a natural system, or a species: capable of recovering from disturbance.
Stochastic	Random; involving a random variable (e.g. a stochastic process). Involving chance or probability (syn: probabilistic) (*WWW Webster Dictionary)*
Stock	1. In theory, a Unit Stock comprises all the individuals of fish in an area, which are part of the same reproductive process. It is self-contained, with no emigration or immigration of individuals from or to the stock. On practical grounds, however, a fraction of the unit stock is considered a "stock" for management purposes (or a management unit), as long as the results of the assessments and management remain close enough to what they would be on the unit stock. 2. A group of individuals in a species occupying a well defined spatial range independent of other stocks of the same species. Random dispersal and directed migrations due to seasonal or reproductive activity can occur. Such a group can be regarded as an entity for management or assessment purposes. Some species form a single stock (e.g. southern bluefin tuna) while others are composed of several stocks (e.g. albacore tuna in the Pacific Ocean comprises separate Northern and Southern stocks). The impact of fishing on a species cannot be determined without knowledge of this stock structure.
Target Species	Those species that are primarily sought by the fishermen in a particular fishery. The subject of directed fishing effort in a fishery. There may be primary as well as secondary target species