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THE PRECAUTIONARY APPROACH TO FISHERIES WITH REFERENCE TO STRADDLING FISH STOCKS AND HIGHLY MIGRATORY FISH STOCKS

Explanatory note

The United Nations Conference on Straddling Fish Stocks and Highly Migratory Fish Stocks, at its second session, held in New York from 12 to 30 July 1993, requested the Food and Agriculture Organization of the United Nations (FA0) to prepare an information paper on the precautionary approach in fisheries management (A/48/479, para. 17 (c)). Pursuant to that request FAO has provided the present information paper.

I. SUMMARY

1. The present status of many fishery resources around the world indicates that management practices need to be improved and particular attention is required for high seas fisheries. The uncertainty and related risk resulting from intrinsic inefficiencies in fisheries management, insufficient scientific information and natural variability (including climate change) is progressively being recognized and taken into account. An acceleration of the process of evolution of fisheries management and a broadening of its scope are required to take fully into account both the explicit requirements of the 1982 United Nations Convention on the Law of the Sea and those of Agenda 21 of the United Nations Conference on Environment and Development. A global trend is developing in favour of the concept of precaution, which should now also be considered for implementation in fisheries management.

2. The concept of precaution requires management authorities to take pre-emptive action where there is a risk of severe and irreversible damage to human beings and, by extension, to the resources and the environment, even in the absence of certainty about the impact or the causal relationships. When there is doubt about the effect of a technology or fishing practice on the marine environment and resources, preventive or remedial action would have to be taken, erring on the safe side, with due consideration to the social and economic consequences.

3. The need for precaution in management is reflected in two main concepts: the precautionary principle and the precautionary approach. The precautionary principle has suffered from a lack of definition and slack usage leading to extreme interpretations regardless of economic and social costs. It has therefore developed a strong negative undertone. The precautionary approach, which implicitly recognizes that there is a diversity of ecological as well as socio-economic situations requiring different strategies, has a more acceptable "image" and is more readily applicable to fisheries management systems.

4. Precautionary management measures have often been advocated in the past but they have rarely been implemented because of their potential short-term costs. On the one hand, they are needed to improve fisheries management and ensure more sustainable fisheries development, reducing risks for the resources and for fishing communities. For this purpose it is recommended to use more precautionary management reference points than in the past. On the other hand, overly stringent measures could lead to economic and social chaos in the fishing industry.

5. The requirement laid down in the Convention on the Law of the Sea for the "best scientific evidence available" remains the first condition for effective and equitable management and the concept of precaution does not exempt fishing States and management authorities from their responsibilities to build up the necessary scientific information and cooperation. The best scientific evidence could be viewed as the most statistically sound evidence.

6. In a situation of high potential risk and lack or inadequacy of information, the concept of precaution requires that the onus of scientific

proof (e.g., in the form of an environmental impact assessment) be on those who intend to draw benefits from the resource and contend that there is no risk (reversal of the burden of proof).

7. The precautionary approach propounds caution in all aspects of fishery activities: in applied fishery research, in management and in development. It can easily be translated into a "tool-box" of precautionary measures among which appropriate ones can be selected for different situations. It would be consistent with the internationally agreed principles of sustainable development and those of responsible fishing and would, inter alia:

- Promote the collection and use of the best scientific evidence;
- Adopt a broad range of reference points;
- Agree on a set of rules and guidelines;
- Adopt action-triggering thresholds;
- Agree on acceptable (tolerable) levels of impact and risk;
- Improve participation of non-fishery users;
- Improve decision-making procedures;
- Promote the use of more responsible technology;
- Introduce prior consent or prior consultation procedures;
- Strengthen monitoring, control and surveillance;
- Adopt experimental management and development strategies;
- Institutionalize transparency and accountability;
- Re-establish natural feedback controls.

II. INTRODUCTION

8. The review of the state of world fishery resources undertaken by FAO and the global analysis available in the FAO report on the state of food and agriculture show that, although management practice has evolved during the last half century, it has tended to lag behind management theory and that progress towards sustainability, since the first FAO Technical Committee on Fisheries in 1945, has been insufficient. 1/ It is now recognized that the biomass of many important fish stocks is close to or even below the level that could produce the maximum sustainable yield (MSY), leading to resource instability and economic losses. A number of fisheries have collapsed ecologically or economically and the situation in the high seas raises particular concern.

9. The increased recognition that conventional fishery management needed to be improved has been accompanied by a growing concern for environmental management, particularly as a result of the World Conference on Human Environment (Stockholm, 1972), the FAO Technical Conference on Fishery Development and Management (Vancouver, 1973), the FAO World Conference on Fisheries Management and Development (Rome, 1984), the United Nations Convention on the Law of the Sea (hereafter, the 1982 Convention), the work of the Brundtland Commission from 1984 to 1987 (World Commission on Environment and Development, 1987), the United Nations Conference on Environment and Development (Rio de Janeiro, 1992) and the International Conference on Responsible Fishing (Cancun, Mexico, 1992).

10. Moreover, the emerging awareness of the complexity of marine ecosystems and related scientific uncertainty, particularly in the high seas, and of the risk of error in management requires an acceleration of the evolution of fishery management, a broadening of its scope and a change in attitudes. Two important and related requirements of the new management context are the need for more caution and for better inter-generational equity. The latter issue concerns the ethics of renewable resource use and the moral obligation placed on the current generation to exploit the resources and enact conservation measures in such a manner as to preserve options for future generations.

11. The present paper, prepared upon the request of the United Nations Conference on Straddling Fish Stocks and Highly Migratory Fish Stocks, intends to clarify the concept of precaution and its implications in fisheries with particular reference to straddling fish stocks and highly migratory fish stocks. It has been difficult, however, to focus the analysis solely on these two categories for two reasons. One is that the concept of precaution is general and relevant to all types of fisheries. The second is that the management measures applied to the various parts of a transboundary resource must be consistent. This implies that if the nature of a resource requires precaution, it should be provided throughout its distribution range.

12. The following sections provide a review of: (a) the issues related to uncertainty and risk in fisheries and to the need for caution in management; (b) the requirement for, and formal references to, precaution; (c) the precautionary approach to fishery management; (d) the implications for fishery development; and (e) the implications for fishery research.

III. UNCERTAINTY, RISK AND CAUTION

13. In natural ecosystems, the abundance of a predator is controlled by the abundance of its prey. Excessive predation results in a decrease of the prey abundance and thus a higher mortality and lower fecundity of the predator with, as a consequence, a decrease in its own abundance and predation rate (feedback control). In ecological terms, fisheries are organized predators. As such, their survival depends on the survival of their living resources and they are far more sensitive to natural feedback control than other industrial systems such as those using oceans as a waste dumping area. However, contrary to natural predators, fishermen do not receive sufficient feedback control through signals of resource stress. Their operations are primarily independent of the natural resource ecosystem and, indeed, are protected from such feedback

controls by price increases (as resources become scarcer) and governmental subsidies. They can therefore continue and even expand despite the environmental and resource degradation they may produce. In many areas, this has led to resource erosion, economic losses and social disruptions that illustrate the fisheries management risk and reflect behaviour which in the last decades has been neither sufficiently responsible nor precautionary.

14. Caution is usually required to avoid unwanted effects or limit their probability of occurrence. There is no doubt that fisheries, including those exploiting straddling stocks and highly migratory species, have an impact on the ecosystem, reducing species abundance and reproductive capacity, possibly affecting habitats and genetic diversity. The possible impact on endangered species has also been a source of concern. Some impact on the resource base cannot be totally avoided if fisheries are to produce food and development. Moreover, the biological effects of fishery activities are usually reversible and experience has shown that trends in biomass and species composition can be reversed. However, degraded habitats may require long recovery times and higher rehabilitation costs, but this type of impact is negligible in most high seas fisheries.

15. The necessary impact of fisheries would need to be accurately assessed and forecast in order to propose management options reducing to a minimum the possible risk of severe and costly or irreversible crisis. A major problem is that the properties of fishery resources, their "fluid" nature, the poor quality of fishery data, the limitation of scientific models and research funds, the inherent difficulty of research in the high seas and the fluctuations of economic parameters tend to limit scientific understanding of the fisheries ecosystems. This leads to a degree of uncertainty in the scientific, technical, economic and political information upon which managers and industry leaders base decisions which may not always be wholly appropriate. It must therefore be accepted that errors might be made and have been made.

16. Errors may affect: (a) the basic fishery data used for analysis such as on catches, effort, sizes landed, etc. (measurement error); (b) the estimation of populations and parameters derived from such data (estimation error); (c) the understanding of relationships between the different elements of the fishery system and their interaction (process errors); (d) the way these relationships are mathematically represented (model error); (e) decisions that management takes on the basis of such information (decision error); and (f) the way in which management measures are implemented (implementation error). These errors can lead to two types of situation, where:

(a) Management measures should have been taken but were not and, as a result, the resource is damaged. There are short-term costs for the resource and, possibly, for the fishing community if not compensated by government subsidy. The biological impact is usually reversible if a corrective measure is applied, except perhaps in the case of major damage to the habitat. This type of error may also carry the risk of major economic consequences (as in Peru or, more recently, in Newfoundland);

(b) Management measures may be unnecessarily taken and fishing activities curbed. The cost of the error is borne by the fishery. The biological effects

are usually reversible soon after the measure is suppressed. The socio-economic impact may or may not be reversible (e.g., where there is loss of market).

17. Raising research standards to reduce substantially the risk of error and the level of uncertainty implies requirements for data and financial resources which would often be unrealistic, particularly for high seas resources. It must therefore be recognized that management decisions dealing with actual problems or perceived risks will often be necessarily taken with less than complete and accurate information. A fishery management strategy aiming at no risk at all for the resource and the communities would imply either research costs beyond the value of the fishery or no development at all (in the case of an extreme interpretation of the concept of precaution). Few Governments would find either of these two extreme options viable. Cautious management will therefore deal explicitly with risk and aim at a compromise and it should be clear that the higher the uncertainty and/or risk the greater will be the need for caution, particularly in the selection of management reference points. 2/ An important and difficult task for cautious management authorities will be to promote decisions about the levels of impact (and risk) that are acceptable (tolerable) to society.

18. Particular caution may be necessary when resources and people are in a highly vulnerable situation. This is true, for example, of small island countries where the erosion of natural resources may lead to the degradation of the reef ecosystem and, beyond a certain threshold, to breakdown of development opportunities, life support and social order.

IV. THE REQUIREMENT FOR PRECAUTION

19. The Shorter Oxford English Dictionary defines precaution as "caution exercised beforehand to provide against mischief or secure good results. Prudent foresight. A measure taken to ward off an evil." In environmental management, the meaning generally given to precaution is that of acting in advance to avoid or minimize negative impact, taking into account the potential consequences of being wrong.

20. The concept of precaution seems to have become an important factor in negotiations between States to establish management measures in circumstances where there is an obligation to negotiate in good faith to reach agreement (e.g., with respect to straddling stocks under the 1982 Convention or high seas fishing). Given the wide support for this concept in environmental law, a State which refers objectively to it will hope that it cannot be accused of bad faith.

21. In fisheries, the concept of precaution has been expressed as "the precautionary principle" (hereafter, the principle) or "the precautionary approach". Although the two terms relate equally well to the concept of caution in management, they are differently perceived. The first, because of slack usage, has developed a negative undertone. Radically interpreted, it has sometimes led to an outright ban of a technology and is sometimes considered incompatible with the concept of sustainable use. The second is apparently more generally acceptable because it implies more flexibility, admitting the

possibility of adapting technology, consistent with the requirement for sustainability.

A. The precautionary principle

22. The precautionary principle requires authorities at entrepreneurial, national, regional and international levels to take preventive action when there is a risk of severe and irreversible damage to human beings by technology. Its most characteristic attribute is that, in these circumstances, action is required even in the absence of certainty about the damage and without having to wait for full scientific proof of the cause-effect relationship. In addition, when there is disagreement on the need to take action, the burden of providing the proof is reversed and placed on those who contend that the activity has or will have no impact.

23. The principle has been referred to and applied at the national level in relation to human activities with potentially severe effects on human health (engineering, the pharmaceutical and chemical industries, nuclear power plants, etc.). In international environmental law, the principle has emerged as a recognition of the uncertainty involved in impact assessment and management, particularly in the determination of the immediate and future consequences and associated costs of current decisions for human health, for our resources and for the environment.

24. In the 1970s, following the 1972 Stockholm Conference, concern for human safety was progressively extended to the human environment and to other species. This led to increasingly frequent reference to the principle in international agreements and conventions, often with limited analysis of its practical implications. The principle has been invoked in issues related to the ozone layer, the greenhouse effect and the conservation of nature. It has touched indirectly on fisheries through provisions in the international conventions on dumping at sea (the Paris and Oslo Conventions, Marpol) relating to pollution by fishing vessels.

25. The Declaration of the 1987 International Conference for the Protection of the North Sea contains an example of the concept of precaution in relation to coastal States' jurisdiction, habitats, species and fisheries, including pollution from ships. It provides that "States accept the principle of safeguarding the marine ecosystem by reducing dangerous substances, by the use of the best technology available and other appropriate measures" and that

> "This applies especially when there is reason to assume that certain damage or harmful effects on the living resources are likely to be caused by such substances and technologies, even where there is no scientific evidence to prove a causal link between practices and effects."

26. General Assembly resolution 44/225 of 22 December 1989, on large-scale pelagic driftnet fishing and its impact on the living marine resources of the world's oceans and seas, could be considered a case of radical application of the concept of precaution, despite the lack of explicit reference to the principle. The resolution expressed concern about the size of the fleets, the

length of the nets, their mode of operation, their potential impact on anadromous and highly migratory species, their by-catch and the concern of coastal countries on the state of resources close to their exclusive economic zones. It recommended that a worldwide moratorium should be imposed on all driftnet fishing by 30 June 1992 and it established a set of immediate and regionally tailored interim measures. It also provided that such measures would not be imposed in a region or, if implemented, could be lifted, should effective conservation and management measures be taken upon statistically sound analysis to be made jointly by concerned parties.

27. There is no explicit reference to the principle in the 1982 Convention. Part XII, on "Protection and preservation of the marine environment", does not contain detailed instruments for implementation of the conservation of the marine ecosystem, but it does state in a global instrument, in article 192, the following general obligation: "States have the obligation to protect and preserve the marine environment." In addition, ecosystem conservation also requires measures for the fisheries sector, striking a balance between the provisions for environmental conservation and fisheries management to ensure sustainable exploitation.

28. Fisheries mismanagement is unlikely to threaten the future of humanity and as a consequence radical interpretations of the principle may rarely be justified. Of particular relevance in this respect is the fact that, in its Rio Declaration, as well as Agenda 21 (chap. 17, on protection of the oceans), the United Nations Conference on Environment and Development (UNCED, 1992) referred to the need for a precautionary approach and not to the principle itself.

B. The precautionary approach

29. UNCED stressed the need for a precautionary approach to ocean development in its Rio Declaration and in Agenda 21, particularly in its chapters on the management of coastal areas, resources under national jurisdiction and high seas resources. The following wording, which superficially resembles that of the principle, is subtly different in that it reflects a softer requirement, recognizing that there are differences in local "capabilities" to apply it and calling for "cost-effectiveness" (i.e., taking into account economic and social costs):

> "In order to protect the environment, the precautionary approach shall be widely applied by States according to their capabilities. Where there are threats of serious or irreversible damage, lack of full scientific certainty shall be not used as a reason for postponing cost-effective measures to prevent environmental degradation." (Principle 15 of the UNCED Rio Declaration)

30. The FAO Technical Consultation on High Seas Fishing (Rome, April 1992) addressed the issue. Taking note of the precautionary approach recommended by UNCED, it agreed that fisheries should be managed in a cautious manner but stressed that precautionary management did not necessarily require moratoriums.

31. At its first substantive session, held at New York in July 1992, the United Nations Conference on Straddling Fish Stocks and Highly Migratory Fish Stocks also addressed the issue. It could not reach consensus on the precautionary principle, which many countries equated with a moratorium on fishing and considered too radical for such environmentally soft industries as fisheries. A consensus developed instead on the need to introduce or strengthen the precautionary approach to fishery management. The Inter-American Conference on Responsible Fishing (Mexico City, 1993) also referred to the need to take precaution into account in the Code of Conduct on Responsible Fishing, to be prepared by FAO.

32. Another example of the precautionary approach is given by the form in which the Advisory Committee on Fisheries Management (ACFM) of the International Council for the Exploration of the Sea (ICES) delivers its advice to its member States:

> "For stocks where, at present, it is not possible to carry out any analytical assessment with an acceptable reliability, ACFM shall indicate precautionary total allowable catches (TACs) to reduce the danger of excessive efforts being exerted on these stocks."

33. The implicit assumption is that in the absence of scientific assessments, uncontrolled fisheries are likely to build up overcapacity and overfish the resources. The preventive action is to establish TACs at conservative levels to limit fishing until better assessments become available. The implication is that such conservative measures would be lifted only if better information were provided.

34. In general, the precautionary approach is intended to promote a more equitable balance between short-term considerations (which lead to overfishing) and considerations of a longer-term nature. It also seeks to promote a more equitable balance between the attention given to the needs of present and future generations. Such an approach would address the issue of inter-generational equity (as required by UNCED) and would tend towards reducing the cost of our present decisions for future generations. By comparison, and despite the fact that it aims at sustainability, conventional fishery management addresses primarily, and rather inefficiently, the issue of intra-generational equity and allocation of resources between present users. In the absence of explicit reference to social and economic costs to fisheries, the concept of precaution could lead to imbalance in favour of non-fishery uses and future generations.

35. The concept is also intended to counteract the effects of current high economic discount rates which provide a strong incentive to overfish, maximizing the discounted net benefits from a stock and de facto preferring present consumption over future consumption. 3/ As these rates increase, they prejudice supplies to future generations which the precautionary approach is intended to protect.

36. Moreover, fisheries authorities and industry should not only consider the need to apply the concept of the precautionary approach to their own activities, but should also encourage its use by others whose activities damage the oceans' productivity and the livelihood of fishing communities.

V. THE PRECAUTIONARY APPROACH TO FISHERIES MANAGEMENT

37. Precautionary measures for fisheries management have long been advocated as a means to avoid crises and higher costs to society. These have not often been applied in practice because much attention has been paid to short-term costs while longer-term benefits have not been properly valued. Effective action is needed through which fisheries management should move progressively towards more risk-averse exploitation and management. What is new in the modern requirement for precaution is not so much the sort of management measures that are implied but the way in which such measures should be implemented (i.e., automatically enforced with no exceptions) and when they should be implemented (i.e., as soon as a serious and potentially irreversible effect is detected).

38. An extreme interpretation of the concept of precaution, leading to unnecessarily stringent and costly measures, would rapidly become counter-productive by deterring fishery authorities from using it as widely as possible. The problem is therefore one of promoting effective caution in fisheries to the point where the risk of an irreversible impact on the environment and resources will be reduced below the level which would call for drastic measures with potentially irreversible damage to the fishery sector and the coastal communities. This could be achieved by exerting caution systematically, at all levels of the management process, to reduce substantially the risk of errors.

39. It is often supposed that preventive approaches to management are more precautionary than reactive ones because they anticipate unwanted events through knowledge of the system. A strong and unwarranted assumption behind such suppositions is that there is enough knowledge to allow such events to be reliably anticipated and avoided. Unfortunately, fishery systems are not fully predictable and errors are always likely. As a consequence, a precautionary management strategy would need sufficient preventive capacity to avoid predictable problems with enough reactive (corrective) capacity, flexibility and adaptability to ensure a safe "trial-and-error" process as knowledge about how the system works is collected. Elements to be included in such a strategy are given in section D below.

40. For the same reason, it is not always prudent to rely on deterministic pseudo-quantitative reference points of dubious precision for a target-oriented management (e.g., based on TACs and quotas). More precautionary strategies would recognize the uncertainties in the data and promote adaptability and flexibility through appropriate institutions and decision-making processes. These will rely not only on expert advice but also on people’s participation. In doubtful cases, decisions should "err on the safe side" with due regard to the risk for the resource and the social and economic consequences.

41. A precautionary approach to fisheries management implies agreement on action to be taken to avoid a crisis as well as action required if such a crisis occurs unexpectedly. Agreement on such action, at an international level, implies the existence of agreed standards, rules, reference points, critical thresholds and other criteria. It also implies international consensus on acceptable levels of impact.

A. Management standards, rules and reference points

42. Better quantification and qualification are required for such widely used subjective terms as detrimental, harmful and unacceptable impacts, which are generally used in expressions of the need for precaution. One of the major tasks for research and management is to develop agreement on standards, rules, reference points and critical thresholds on which to base decisions and meet the management requirements of the 1982 Convention and Agenda 21, for the various types of ecosystems and resources.

43. Rules which would be over-restrictive or used without a clear understanding of their practical implications will not lead to consensus on the need for the general application of a precautionary approach. It must also be recognized that because of the generality of conservation principles and the transboundary nature of many resources, rules established for the management of straddling stocks and highly migratory species are likely to be required in the near future for the resource management of exclusive economic zones.

44. The implication is that, although it is likely that only biological criteria can be internationally agreed for transboundary resources, it is in the interest of all coastal States to consider also their potential social and economic consequences if generalized to exclusive economic zones. The following list gives some examples of principles or rules that have been proposed in the literature with a view to illustrating both the need for them and the difficulty of defining them in realistic terms:

(a) Fisheries should not result in the decrease of any population of marine species below a level close to that which ensures the greatest net annual increment of biomass;

(b) Fisheries should not catch amounts of either target or non-target species that will result in significant changes in the relationship among any of the key components of the marine ecosystem of which they are part;

(c) The mortality inflicted on any target or non-target species is unacceptable if it exceeds the level that would, when combined with other sources of mortality, result in a total level that is not sustainable by the population in the long term;

(d) Fish management authorities should set target species catch levels in accordance with the requirement that fishing does not exceed ecologically sustainable levels for both target and non-target species.

45. The first principle implies that populations should not fall below the level of abundance corresponding to MSY, where their annual rate of biological production (turnover) is the highest. This is in line with the 1982 Convention requirements. It has been repeatedly shown, however, that it is often inadvisable to try to extract the MSY from a resource. Moreover, for multi-species fisheries, this principle would require that all species be exploited below their MSY abundance and therefore that the overall level of exploitation be fixed at the lowest level required by the species with the lowest resilience, reducing drastically the utility of the resource. 4/

46. The second principle implies that fishing will not "significantly" disturb the food chain without guidance on how to judge whether an observed or potential disturbance is significant. Moreover, applying the first principle would lead, in practice, to applying different fishing mortalities to different species and this would lead to a change in relative abundance of species, affecting the food chain. As a consequence, the second principle is difficult to use in practice for many fisheries and may not even be consistent with the first.

47. The third and fourth formulations require that all sources of mortality are taken into account when assessing fisheries impact. These would include natural mortality as well as direct and indirect fishing mortalities (through by-catch, drop-out, damage, etc.), a very demanding task.

48. Assuming that the task is feasible, a problem remains with the vagueness of the term "sustainable" in both formulations. In theory, fisheries are sustainable at various levels of stock abundance and rates of harvesting, but these are not equivalent in terms of risk of recruitment collapse. To be of practical use in fishery management, the concept of sustainability needs to be combined with the notion of risk for the resource, and consequently to the fishing communities. 5/

49. The 1982 Convention states that stocks should not be driven below their MSY level of abundance and this could be considered a bottom-line threshold for stock "sustainability" if expressed in terms of probabilities. New reference points, not foreseen in the 1982 Convention, are required if species sustainability is to be ensured at low risk of collapse. Because of the uncertainty inherent in their determination, these reference points should preferably relate to probabilities. 6/

50. Decision rules could also be established on economic grounds, related, for instance, to fishing capacity: e.g., if capacity increases faster than catches for a given number of years, then some capacity freezing action is taken. If capacity is higher than that required to take the allowable catch by more than a given percentage, then it should be reduced, etc. Other economic reference points could be used but to be employed in the management of straddling and highly migratory stocks, they would have to be general enough to be acceptable to all parties and specific enough to be of practical use.

B. Ecosystem management reference points

51. Ecosystem management is being referred with increasing frequency as the necessary basis for fisheries management. This requirement is precautionary in nature in the sense that it requires that the integrity and essential functions of the ecosystem must be preserved as a prerequisite to fisheries sustainability. In practice, however, we do not yet know how to manage ecosystems. If the balance between ecosystem components must be maintained, minimizing by-catch or using extremely selective gear, as common sense suggests, might not be the best solution.

52. It has been proposed, for instance, that, in multi-species management, a reasonable strategy would be to exploit all species in proportion to their

abundance in order to maintain the overall ecosystem structure. This is, however, not easy to achieve without wastage of less demanded species; and additional work is certainly required on this matter before objective guidance can be given.

53. New guidelines and reference points are needed for a precautionary approach to ecosystem management, related to global stress indicators, resilience factors, habitat conditions, etc. Measures or scales of ecological stress need to be established and agreed upon if usable reference points are to be provided and effects classified as acceptable/unacceptable from an ecosystem point of view.

54. Clarification is also required, for example, on the measure of "sustainability" for an ecosystem and on the definition of "reversibility" of an impact on it. Ecosystems have a degree of natural variability and can shift from one equilibrium state to another because of natural environmental variability or human stress. Sustainability should therefore not be confused with constancy. As far as reversibility is concerned, fisheries management may be able to suppress unwanted fisheries impacts and rebuild productivity but there is no assurance that the ecosystem could be returned exactly to its "pristine" state.

55. Some of the aims and principles of ecosystem management can be found in the management charter of the Commission for the Conservation of Antarctic Marine Living Resources (CCAMLR) and in the 1990 Strategy for Sustainability elaborated by the World Conservation Union (IUCN). These include: minimizing conversion of critical ecosystems to "lower" conditions, compensating habitat conversion with restoration (allowing no net loss), 7/ maintaining ecological relationships, maintaining populations at greatest net annual increment, restoring depleted populations, minimizing risk of irreversible change in the marine ecosystem, etc.

56. Genetic conservation guidelines, when introduced, will make matters even more complicated as management will have to meet conservation requirements at the ecosystem/biodiversity, species and genetic levels. Nevertheless, the definition and analysis of management reference points and the behaviour of stocks and risks attached to those points should be one of the main applied research issues of the next decade if a precautionary approach to management is to be implemented.

57. The above considerations related to standards, rules and reference points demonstrate that a precautionary approach to management requires a thorough scientific effort to develop the scientific tools. Without these the concept of precaution will remain at the level of international rhetoric.

C. Acceptable levels of impact

58. If development and benefits are to be obtained from straddling and highly migratory fish resources, some level of impact has to be accepted. In fisheries, a zero-impact strategy would make no sense. It is therefore necessary to: (a) identify and forecast fishery effects (and risks) accurately

enough, (b) agree on acceptable levels of impact (and risk) and (c) develop management structures capable of maintaining fisheries within these levels.

59. The concept of "acceptable levels of impact" may be related to that of "assimilative capacity" which has generated considerable debate amongst those concerned with environmental protection. The latter implies that nature can absorb a certain quantity of contaminants without significant effect (e.g., the dumping of processed effluents from urban concentrations, radioactive waste, heavy metals and other causes of dramatic and potentially non-reversible impacts). However, with fisheries the problem is different. Fishery resources do possess an assimilative capacity in terms of the fishing mortality they can withstand while still conserving most of their resilience or capacity to return to their original state once the fishery-induced stress is removed. In a way, MSY could be considered a reference point corresponding to the "maximum assimilative capacity" of a stock in terms of fishing stress, a value fisheries should not pass and perhaps even not approach. 8/ The principles listed above imply an acceptable level of impact. The situation becomes more complex when considering the assimilative capacity of a multi-species resource or an ecosystem for which no means of measurement are yet available.

60. An acceptable level of impact (or risk) may be defined as a level which will never be fully accepted (in the sense of definitely approved) but that will be kept continually under review and eventually modified as knowledge progresses. The degree of acceptability of impacts (or risks) will be determined, inter alia, in terms of risk-benefit trade-offs with proper weighting given to long-term needs and natural assets. This requires research capacity to separate the effects of "natural" year-to-year fluctuations and the impacts of fishing from anthropogenic degradation, including global climate change. It requires the development of an effective enforcement capacity to ensure that such levels will be respected. Finally, it requires the establishment of "safety net" arrangements (e.g., in terms of insurance, compensation, etc.) to protect the users and the resource from hazardous occurrences.

61. There is no scientific way of determining objectively what is and what is not acceptable to society. An important prerequisite for the effects of fishing to be acceptable is that they should be reversible if the fishing pressure is reduced or suppressed. It is likely that what may be acceptable to some countries or user groups may not be acceptable to others, and the relevance and importance of traditions and culture should not be underestimated. Science has to provide methods to assess the impacts and objective criteria to help to reach agreement. The difficulty in this regard will not be less than in determining MSY and we should expect considerable scientific argument on the type of impact one might expect and on the level of certainty with which it can be determined. The degree of acceptability of any impact will only be established after intense negotiations between the parties concerned. These are unlikely to proceed easily or rationally if undertaken in a context of crisis. It is therefore advisable to integrate negotiations on impact into the management process before stocks are damaged and before potential socio-economic problems reach an overwhelming level.

D. Practical guidance for management

62. A fishery management policy based on a reasonable interpretation of the concept of precaution should: (a) explicitly adopt the principle of sustainable development as defined by the FAO Conference, 9/ (b) select a set of objectives broadly compatible with it and (c) adopt a precautionary approach based on the following measures:

(i) Use the best scientific evidence available and, if it is not sufficient, invest in emergency research while interim management measures are taken at the level required to avoid irreversible damage;

(ii) Improve information systems. The cost could be covered through fishing fees and will need to be commensurate with the level of risk. All resources, directly or indirectly affected, should be covered. International and regional arrangements should actively promote the development of joint research programmes;

(iii) Adopt a broader range of reference points and management benchmarks more explicitly related to the objectives selected for the fishery and use them to measure the efficiency of the management system (e.g., related to capacity);

(iv) Agree on a set of criteria and rules before a crisis develops. They would be the basis for agreement on the degree of harmfulness of a new fishing technique or practice;

(v) Agree on acceptable levels of impact (and risk) in a process that will identify trade-offs and promote transparency, particularly in relation to public opinion;

(vi) Take into account the combined stresses on resources and environment. Effort reductions may be imposed or special measures affecting fisheries taken when the stock faces unusually unfavourable environmental conditions;

(vii) Manage fisheries in the context of integrated management of coastal areas, raising sectoral awareness about exogenous impacts on fisheries productivity;

(viii) Adopt action-triggering thresholds and management strategies which include pre-agreed courses of action, automatically implemented if the stock or the environment approaches or enters a critical state as defined by pre-agreed rules, criteria and reference points; 10/

(ix) Improve participation of, and dialogue with, non-fishery users, taking all interests into account when developing and managing fisheries. This is required by Agenda 21, necessary for the long-term survival of fisheries and implies improving management transparency and reporting procedures;

(x) Improve decision-making procedures. Decisions by consensus can only lead to ineffective agreement at the level of the lowest common denominator. Introducing voting procedures or using them when they already exist would improve the situation;

(xi) Strengthen monitoring, control and surveillance, thereby improving detection and enforcement capacity (including legal tools), raising penalties to deterrent levels and exerting more vigilant and effective flag State and port State responsibilities;

(xii) Experiment with management strategies and development projects with the support of research. When a risk for the resources is foreseen, the response to possible management strategies and the impact of development projects should be tested on a pilot scale and environmental impact assessments should be conducted.

63. A precautionary approach to fishery management does not require that all of these precautionary measures be implemented in all fisheries at all times. The type of action required and its degree of urgency is a function of the probability of occurrence of a certain type of impact of a certain magnitude, pre-agreed as part of the management scheme, and based on appropriate reference points. Decisions on what should or should not be allowed are comparatively easy when risks are known and extremely high. Proposals to prohibit, even without any scientific background, the use of explosives to fish in the high seas would probably not meet with much international opposition because harmful fisheries techniques (e.g., dynamite and poison) are normally banned by national fisheries legislation. However, deciding whether a 5 per cent by-catch of sharks in a long-line tuna fishery is acceptable would require more careful consideration.

VI. IMPLICATIONS FOR DEVELOPMENT

A. The concept of responsible technology

64. In international environmental law, the principle is often associated with the requirement to use the "best available technology", an obvious parallel to "best scientific evidence available". This wording has sometimes been interpreted as requiring the technology which has the smallest environmental impact, regardless of the short-term socio-economic costs. This interpretation has, however, been contested on the basis that such technology might not always be affordable by all countries and, in particular, by developing ones. 11/

65. General Assembly resolution 44/228 of 22 December 1989 on UNCED referred instead to "environmentally sound technology", stressing the need for socio-economic constraints to be taken into account. The wording does not pretend to limit the choice to a single "best" or soundest technology, implying that many sound technologies may be used together.

66. The Cancun Declaration (Mexico, 1992) provides that "States should promote the development and use of selective fishing gear and practices that minimize waste of catch of target species and minimize by-catch of non-target species".

If social and economic factors are taken into account, in line with the concepts of sustainable development and responsible fishing, the technological requirements should be defined with a view to maintaining (or reducing) the accidental effects of capture and post-capture fishery activities within pre-defined acceptable (tolerable) levels, allowing general application by all countries.

67. In environmental law, technologies are often catalogued on separate lists, the "colour" of which reflects the perceived degree of environmental friendliness. "Black" or "red" lists refer to technologies with unacceptable impacts. "Grey" and "orange" lists refer to technologies usable under some conditions. "Green" lists contain those technologies believed to be harmless or producing only acceptable levels of impact. 12/

68. This approach has been indirectly applied to fisheries by reference to the Convention on the Conservation of European Wildlife and Natural Habitats (Bern, 1979). That Convention gives, in its annex IV, a list of non-selective gear to be banned, which includes all nets. Although it had been designed for migratory birds, the list has been referred to, in Italy, in connection with the banning of large-scale pelagic driftnet fishery. The importance of nets in fisheries and their contribution to the livelihood of small-scale fishermen and indigenous people illustrates the need for careful consideration before referring to lists contained in non-fishery agreements and before elaborating specific lists of fisheries.

69. Considering that, in fisheries, the concept of responsible fishing is well defined and that a Code of Conduct for Responsible Fishing will be adopted, it may be of value to refer to the requirement for "responsible fishery technology" (including capture and post-capture technology) as defined in the Code. Responsible technology will have to be used in all areas of fisheries, including capture, land-based or sea-based processing and distribution. Although some general guidelines can be given, based on known characteristics of types of resources and technology, the most responsible mix of technologies to be used in a particular fishery will be agreed on a case-by-case basis with explicit reference to the agreed management reference points and acceptable levels of impact agreed for that fishery.

70. Moreover, a "better" technology might be theoretically available on the market but in effect not accessible to some countries because of its cost or its sophistication. It is clear that in many instances the general use of the "best technology" will require an improvement in international cooperation in technology transfer, as underscored in Agenda 21. 13/

B. Prior informed consent and prior consultation

71. In dangerous polluting industries, reference has often been made to prior informed consent and prior consultation procedures. The practical significance is that, before introducing a new technology in a controlled or sensitive area, the proponent must produce a substantial amount of information about the technology to be introduced and its potential impact and, eventually, obtain the consent of the other users. 14/ If the introduction is agreed, a number of

specific measures are usually foreseen such as limiting the scale of the initial project, special monitoring and reporting requirements, etc.

72. The general application of prior informed consent or prior consultation procedures to capture fisheries would require further consideration and clarification. 15/ This might be considered for some particularly efficient and potentially dangerous technologies and/or for particularly vulnerable resources or fragile ecosystems when severe, irreversible effects are possible. Prior informed consent of the regional management authority could be required before introducing the new methodology. The procedure may be better accepted if the new technology is patented, limiting the risk that the benefits to the "discoverer" will be jeopardized.

73. In practice, a State proposing to introduce a new technique would be requested to present a report, comparable to an environmental impact assessment. Such an assessment would address potential effects on the target species and on associated species which might be targets for other fisheries in the area or food items for such target species. However, apart from its scientific complexity, it is clear that such impact assessment cannot be conducted in the absence of at least a pilot fishery. The administrative burden this imposes could be overwhelming and the procedure should remain exceptional. The special monitoring and reporting procedures could also be used for activities recognized as unacceptable in the long term and for which phasing out has been decided. Interim reports could be requested during the phasing out period.

74. In the case of high seas areas not covered by any specific international agreement, there would be no competent authority to which the request for prior consent could be made. In addition, there would also be no monitoring or enforcement system in place, making it impossible to detect the introduction of harmful techniques and to measure impact. This is a case where the legal responsibilities of the flag States would need to be clearly determined, especially if the flag State registers all vessels authorized to fish in the high seas as provided for in the 1993 Agreement on the Promotion of Compliance with Conservation and Management Measures by Fishing Vessels in the High Seas.

VII. IMPLICATIONS FOR FISHERY RESEARCH

75. All expressions of the concept of precaution require that "lack of full scientific certainty shall be not used as a reason for postponing cost-effective measures to prevent environmental degradation" (principle 15 of the Rio Declaration). The requirement for precaution may therefore appear to require no input from fishery research. In practice, however, the effective implementation of precaution requires substantial support from fishery science, which needs to be adapted to the new requirements.

A. The "best scientific evidence"

76. Prior scientific consensus on cause-effect relationships and potential consequences of fishing has been the basis for cooperation in international fisheries management in the past. It should continue to be one of the most

neutral and peaceful contributions to the resolution of conflict between nations and competing user groups.

77. The Christiania Conference, in 1901, held just before the creation of the International Council for the Exploration of the Sea (ICES), endorsed the principle of scientific inquiry as a basis for rational exploitation of the sea. The same principle was also agreed at the International Conference on the Conservation of the Living Resources of the Sea, hosted by FAO (Rome, 1955). More recently, the 1982 Convention provided that the best scientific evidence shall be taken into account by the coastal State when designing and adopting management and conservation measures in exclusive economic zones (article 61). For the high seas, this Convention provides that measures are designed on such scientific evidence (article 119). More recently, General Assembly resolution 44/225 recognized, in its preamble, that "any regulatory measures ... should take account of the best scientific evidence available".

78. The 1982 Convention does not define the quality of the evidence required in any quantitative manner. The requirement that the evidence should be the best available implies that even poor evidence can be used in designing conservation measures provided it is recognized as the best available. The 1982 Convention does not provide any guidance on how to decide which is "the best" scientific information (see note 16). Nor does it indicate how to operate in the absence of scientific consensus which it implicitly assumes or when no scientific information is available at all.

79. Although the 1982 Convention does not foresee that an existing fishery could be closed if not enough scientific information is available, it does not impose a great burden to be discharged before the necessary conservation measures can be taken. One would assume therefore that, in such a case, the spirit of the Convention is that the missing scientific information should be urgently collected but this does not preclude measures being taken in the meantime. The concept of precaution would ensure that action is not deferred sine die.

80. Concern has been expressed that the principle could imply that scientific facts to back up management decisions were no longer necessary. There is an obvious risk that, by referring to the concept of precaution, scientific objectivity could be less rigorously applied and that international dialogue could be negatively affected. It is hardly debatable that when scientific data are available together with a monitoring and management system, the basic requirement of the 1982 Convention should prevail, and decisions should be taken on that basis. 16/ Emergency action in the absence of scientific consensus should therefore only be justified when there is the risk of severe and irreversible effects and the concept of precaution may be seen as filling the gaps in the 1982 Convention, preventing the absence of scientific data or consensus from opening a loophole leading to "laissez-faire" management and development strategies with damaging or irreversible consequences.

81. In an international fishery management body, a State willing to invoke the need for a precautionary approach in order to promote management measures would have to convince the other parties that exceptional conditions are met for its application: that there is indeed a high risk of severe and irreversible

damage. Science should demonstrate the existence and extent of risk through risk analysis. If the available information was considered insufficient to demonstrate objectively the risk, the application of the concept of precaution could become counter-productive. In such a case the management authority would face "perceived risks", in the absence of objectively demonstrated ones. This is often the case with global societal risks and consensus will have to be achieved through a purely political process involving as much consultation and transparency as possible.

B. The burden of proof

82. In practice, the burden of proof has fallen traditionally on research and management. It has been necessary to demonstrate, with the available data, that harm could be (or was) done to the stock or that fisheries performance could be improved before management measures could be imposed. In many instances, this approach was not effective because fishery research usually lagged behind development. Both the principle and the precautionary approach imply that action might have to be taken without full evidence of the extent of the risk and of the causal relationships.

83. When international consensus on what action to take cannot be obtained because of insufficient information, it has been suggested that the burden of proof be reversed, placing on those who derive benefits from the ecosystem the responsibility to prove that what they intend to do will not lead to "severe and irreversible" effects on the resources. In such a case, the burden of demonstrating that industrial business is conducted in a responsible manner would be on industry.

84. As an example, General Assembly resolution 44/225 recommended a total ban on large-scale driftnet fishing in the absence of scientific consensus on the likely long-term impact, implying that the prohibition of a disputed fishing technique is in order until its acceptability has been demonstrated. It stated that:

> "such a measure will not be imposed in a region or, if implemented, can be lifted, should effective conservation and management measures be taken based upon statistically sound analysis to be jointly made by concerned parties ...".

85. This resolution reversed the conventional course of action, recommending immediate and drastic action (i.e., a total ban of the offending gear) on the basis of international concern assuming that driftnets had an undesirable impact on resources, until shown otherwise. It was agreed that such action could, in principle, be reversed should the joint scientific analysis lead to consensus on the effectiveness of management measures. The resolution, however, gave no guidance or criteria on how to judge the quality or adequacy of the available evidence or the effectiveness of the management measures.

86. The action was confirmed by General Assembly resolution 46/215 of 20 December 1991, which called for action against this type of fishing on the basis that:

> "the international community [has] reviewed the best available scientific data and [has] failed to conclude that this practice has no adverse impact ... and that ... evidence has not demonstrated that the impact can be fully prevented".

87. Another example of reversal of the burden of proof can be found in Council Regulation 345/92 of the European Economic Community (EEC), which regulated the use and the length of driftnets (limited to 2.5 km) in EEC waters. Article 9(a) granted a derogation until 31 December 1993 to some vessels for the use of longer gear, stating that:

> "The derogation shall expire on the above-mentioned date, unless the Council, acting by a qualified majority on a proposal from the Commission, decides to extend it in the light of scientific evidence showing the absence of any ecological risk linked thereto."

88. The concept of reversal of the burden of proof implies that, unless proved otherwise, some fishing techniques may be considered harmful, giving systematically to the resources the benefit of doubt. It may be taken as implying that fishing techniques, which would not be formally authorized in a management area or for a particular species, would be forbidden. The requirement is related to the notion that an environmental impact assessment should be presented before a new technology or practice is introduced in an ecosystem. It is also related to the concept of prior consent or prior authorization discussed in section VI.B.

89. Under this concept, the industry and fishing communities would bear the cost of research and may have to forego some income-generating activities if they are unable to convince the authorities of the acceptability of the technique. It would be fair to give the people whose activity and livelihood are threatened by the measure the opportunity to develop the proof required within a given time span.

90. It is usually impossible to forecast, with any degree of accuracy, the impact that a new fishery will have before it starts and some data are collected. It might therefore be imagined that no new fishery could be developed because evidence of the absence of adverse impact cannot be given by those involved in the venture. A precautionary approach, in such a case, should lead to agreement for a pilot fishery large enough to collect data and build up the scientific evidence required, but small enough to ensure that no irreversible effect is likely. In practice, there will usually be a trade-off: a small amount of risk for the resources being exploited will have to be accepted in exchange for the possibility to provide food and a livelihood for humans.

91. Meanwhile, and in accordance with the precautionary approach, interim precautionary measures may be taken giving due consideration to the actual nature and level of risk for the resource, and to the social and economic costs to the community. Therefore, banning fishing techniques would be extreme measures, justified only when the risk of irreversible damage to the resource or the community is high. It is suggested that wide application of the concept of

reversal of proof in fishery management operations would lead to considerable economic damage and discredit the concept of precaution itself.

C. The role of statistical methods

92. The 1982 Convention does not give any indications on how to determine which scientific evidence is the "best". General Assembly resolution 44/225 required "sound statistical analysis" and this new terminology could be considered an attempt to clarify further the concept of "best evidence", equating it with "statistically sound evidence". The advantage of incorporating statistics into the concept is that it offers a way of using well-established mathematical techniques and tests. It also forces scientists and decision-makers to recognize and measure explicitly the levels of uncertainty and the risks attached to these decisions.

93. Scientists still must agree on which type of statistical methods to use (parametric, non-parametric, geostatistics) and which test is most appropriate for a particular problem. Fisheries do not usually conform strictly to the requirements for unbiased application of conventional statistical methods and the reliability of many statistical tests might still be a matter for debate. As a consequence, obtaining consensus on the "best statistical analysis" to use might not always be easy. The best statistical methods applied to unreliable data can only lead to unreliable results. It is therefore obvious that rigorous statistical methods should also be applied in data collection systems. This is particularly critical for fisheries data.

D. Practical guidance for research

94. The preceding discussions indicate that a major contribution of fishery science to the development of a precautionary approach to fishery management would be:

(i) To promote multidisciplinary research, including social and environmental sciences, because the availability of biological evidence has not prevented overfishing;

(ii) To expand the range of fishery models (bio-economic, multi-species and ecosystem models), taking into account environmental, species and technological interactions;

(iii) To analyse various possible management options using the whole range of available models, showing the likely direction and magnitude of the biological, social and economic consequences, the related levels of uncertainty and the potential costs (risk assessment). In situations of doubt and high risk of irreversible damage to the resource, scientists analysing options for management should systematically analyse and highlight the most pessimistic scenarios; 17/

(iv) To develop scientific guidelines and rules for multi-species and ecosystem management as a basis for agreement on acceptable degrees of disturbance. Because of the inherent uncertainty in research, conventional, quantitative reference points and thresholds will have to be agreed on; 18/

(v) To improve statistical methodologies for assessing the biological and economic parameters, testing their sensitivity to uncertainties in the data used and systematically estimating bias and precision in the derived parameters. The sensitivity of models to uncertainties in their parameters and functional structure should also be tested;

(vi) To improve understanding of environmental impact, raising the awareness of fishermen to the possible impact on fisheries potential resulting from fisheries as well as from environmental degradation caused by other industries. Environmental Impact Assessments should be used more frequently. Research is needed on better ways to use gear and also on the development of better gear with better selectivity and less long-term environmental impact.

Notes

1/ The inadequacy in management of straddling and highly migratory resources (and of many exclusive economic zone resources) results essentially from the common property nature of the resources and the lack of effective mechanisms to directly control fishing effort levels in the absence of an explicit agreement on the allocation of resources between users.

2/ For more detailed analysis on uncertainty and management reference points the reader is referred to the paper prepared by FAO for the present Conference on "Reference points for fisheries management: their potential application to straddling and highly migratory resources" (A/CONF.164/INF/9).

3/ This factor often leads to proposals to introduce a social discount rate. However, there are severe practical difficulties in determining such rates and implementing them. A more satisfactory solution would appear to be through proper pricing of resources, including not only the marginal cost of harvesting, but also the foregone value of catches no longer available to future generations.

4/ In a typical Mediterranean multi-species trawl fishery, where long-lived bottom species (e.g., seabream and red mullet) are targeted together with short-lived pelagics (e.g., sardine), this would imply fishing sardine well below the possible level of harvest in order to comply with the guidelines for seabream and mullet. The problem has been recognized in the report of the FAO Expert Consultation on Large-Scale Pelagic Driftnet Fishing (Rome, 1990).

5/ Surplus production models, on which the concept of MSY is based, assume that natural renewable resources are "sustainable" (i.e., able to regenerate themselves year after year) at various levels of abundance depending on the level of harvest. A stock can in theory reproduce itself, and be

considered sustainable, at high (virgin state), medium (MSY level) and even low levels of abundance, except for some species such as marine mammals and sharks. However, as stocks are fished down, their variability and the risk of collapse increases and it should be clear that all levels of theoretical "sustainability" are not equivalent in terms of risk for the resource.

6/ For instance, a "minimum biological acceptable limit" related to recruitment or reproductive biomass would be a threshold beyond which the recruitment has a given probability to decrease or when the residual spawning biomass (escapement) falls to, say, 20 per cent of the virgin spawning biomass. Pre-established measures triggered automatically at threshold levels would be particularly advisable in areas of high environmental variability (upwellings) or for species with particularly low resilience (e.g., small cetaceans, sharks, etc.).

7/ This concept of "compensation", which proposes that human activities should lead to "no net loss of habitat", implies that, if some part of a habitat must be damaged somewhere, compensation is provided somewhere else.

8/ Research has amply demonstrated during the last two decades that even at MSY, stock instability and risk of recruitment failure are sometimes already high. This, added to the fact that MSY and the fishing rate corresponding to it are usually difficult to determine accurately, should lead us to consider MSY as a non-precautionary target for stocks with low resilience or high natural variability.

9/ "Sustainable development is the management and conservation of the natural resource base, and the orientation of technological and institutional change in such a manner as to ensure the attainment and continued satisfaction of human needs for present and future generations. Such development conserves land, water, plant genetic resources, is environmentally non-degrading, technologically appropriate, economically viable and socially acceptable."

10/ One of these courses of action could be a moratorium, but if reference points are selected on a cautious basis and monitoring produces information on a quasi-real-time basis, a range of actions is available (seasonal or temporary closures, modification of fishing patterns, significant reduction of effort, etc.).

11/ A discussion on this issue can be found in: "Environmental capacity. An approach to marine pollution prevention", GESAMP Report and Studies, No. 30, 1986.

12/ The classification of a technology will depend on the type of habitat. Heavy trawls may be considered "green" on deep muddy grounds but "red" in shallow estuaries and coastal zones or coral reefs. Artificial reefs might be on a grey or orange list because their impact on coastal habitat is long lasting and, if made of derelict material, they may contaminate the environment.

13/ The successful efforts made by the Inter-American Tropical Tuna Commission in the Eastern Central Pacific area to train crews of the region in

effectively avoiding by-catches of dolphins through the use of appropriate technology is a good example of what can be achieved in this respect.

14/ An example can be found in the Code of Practice to Reduce the Risk of Adverse Effects Arising From Introduction and Transfers of Marine Species including the Release of Genetically Modified Organisms which has been adopted by the International Council for the Exploration of the Sea and the European Inland Fishery and Advisory Commission of FAO. The Code foresees that "Member countries contemplating any new introduction [of genetically modified organisms] should be requested to present to the Council, at an early stage, information on the species, stage in the life cycle, area of origin, proposed plan of introduction and objectives, with such information on its habitat, epifauna, associated organisms, potential competitors with species in the new environment, genetic implications, etc., as is available. The Council should then consider the possible outcome of the introduction, and offer advice on the acceptability of the choice."

15/ In exclusive economic zone fisheries, where effective effort controls have been established, there is often a requirement to obtain prior consent from the management authority before a new vessel is ordered or even before the banks are approached for a loan for this purpose.

16/ It should also be clear that in order to satisfy the requirement of the 1982 Convention for the best scientific evidence available, the information must be scientific (i.e., obtained and presented in an objective, verifiable and systematic manner) and it does need to be made "available" to all concerned. This, in the context of straddling and highly migratory resources, requires the existence of effective international scientific cooperation and the elimination of non-reporting and misreporting.

17/ Models which predict rapid collapse when effort develops beyond the MSY level (such as the Gulland-Schaefer production model or the Ricker stock-recruitment model) should be used rather than models assuming high resilience of stocks at high fishing rates (such as the Fox production model or the Beverton and Holt yield-per-recruit and stock-recruitment models).

18/ For instance, if it is agreed that it is safe to exploit a resource at two thirds of its MSY, it will be necessary to agree on the reference data set and on the conventional model on which to base the calculations because the true value of 2/3 MSY and of its corresponding level of effort will never be exactly known and may vary according to the model used.
