Marine and coastal stocking: global status and information needs

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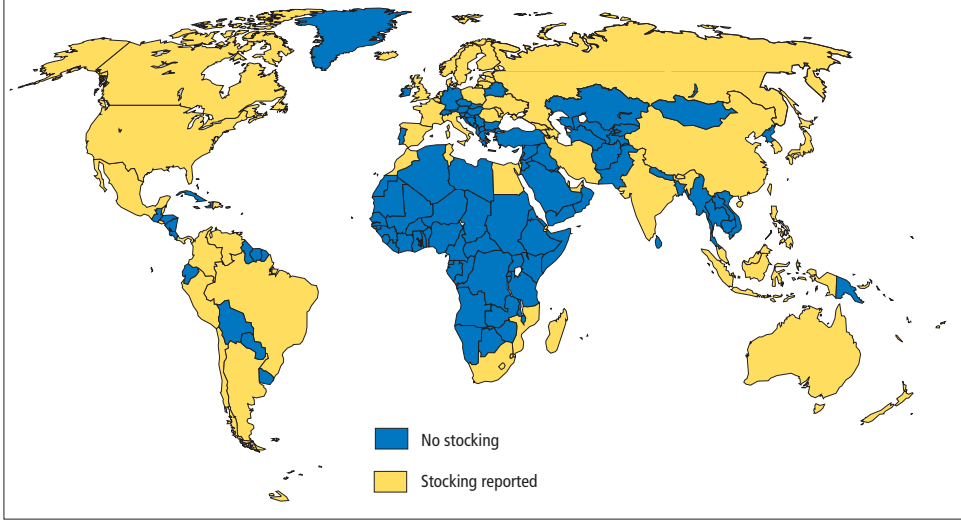
ABSTRACT

Production from many of the world's fisheries has remained constant over recent years and is not expected to keep up with a growing human population's demands for fishery products. In addition, environmental degradation and poor fisheries management have caused several of the world's fisheries to decline and even collapse. Stocking of early life history stages of fish is one fishery management option that is being used to address the need for continued production from marine and coastal areas.

We reviewed information that Members provided to the Food and Agriculture Organization of the United Nations (FAO) and scientific and "grey" literature to assess the status of stocking programmes worldwide and to assess the information available to evaluate such programmes (Figure 1). Analysis revealed, *inter alia*, that between 1984 and 1997, 64 countries reported the stocking of species that spend a part of their life in marine and coastal areas. Japan is the world leader in marine stocking, however, many of the stocking programmes are experimental or pilot scale. Review of the literature uncovered only a fraction of the global activity in stocking, partly because many government programmes are not published. Conversely, several countries that

FIGURE 1. Countries with reported Marine Stocking



document their stocking programmes in the scientific literature did not report any stocking information to FAO. Many believe that stocking will become an increasingly important fishery management tool in the future. However, the practice must be evaluated and monitored accurately.

Worldwide, 64 countries reported some activity in marine and coastal stocking with approximately 180 different species being released of which 46 species are confined to marine environments. The species used are generally not widespread, except for several salmonids. Europe and North America have relatively the highest number of countries that reported marine and coastal stocking, Africa and Latin America show a lower effort with an intermediate position for Asia and Oceania.

Currently, inconsistencies in reporting and monitoring hinder accurate assessment of many stocking programmes. Standardized nomenclature and reporting format are suggested that will facilitate data reporting and enable resource managers and development agencies to evaluate more accurately the role of stocking programmes in marine and coastal areas.

INTRODUCTION

Production from many of the world's fisheries has remained constant over recent years and is not expected to keep up with a growing human population's demands for fishery products. In addition, environmental degradation and poor fisheries management have caused several of the world's fisheries to decline and even collapse. Stocking[1] of early life history stages of fish is one fishery management option that is being used to address the need for continued production from marine and coastal areas.

Hatchery enhancement of marine and coastal stocks[2] has been criticized on the grounds that it is not effective, not economically feasible, prevents alternative solutions from being implemented (sound fishery management, habitat restoration) and that it endangers native aquatic resources (genetic interactions, competition) (Bartley, 1996). Stocking is one of the options to augment, maintain or restore fisheries production and it should preferably be accompanied by sound fisheries management (e.g. minimum mesh sizes, closed seasons etc.) to achieve it is maximum benefit. A good example is the recovery of red drum stocks in Texas through the initiation of an overall recovery plan including stocking and fisheries regulations (McCartey *et al.,* 1993). Unfortunately, fisheries regulations are often difficult to enforce and as a result stocking is being used in situations of sub-optimal fishery management and over-exploitation. It has been adopted by Governments as a clearly visible measure to support fisheries without knowing the exact causes for decreasing capture fisheries. In these situations stocking programmes may fail and the conclusion is drawn that marine stocking is not working.

Marine stock enhancement has a history of controversy, partly because of lack of proper monitoring and data recording. Given the renewed interest in marine stock enhancement in the last 20 years and it is history of mixed results it is important to keep track of the trends and developments. Governments and development agencies are becoming more critical to stock enhancement and it will be important to provide

[1] The terms (sea) ranching, marine stocking, marine stock enhancement and hatchery enhancement have all been used to describe release of hatchery-raised animals into the wild. For the purpose of this document no distinction is made between these terms, although subtle differences in meaning do exist.

[2] For the purpose of this paper we use the term "marine stocking" for stock enhancement of both marine and coastal stocks.

them with sufficient information regarding the status of this management option. This is even more important because many believe that stocking will become an increasingly important fishery management tool.

We reviewed information that Members provided to FAO and scientific and "grey" literature to assess the status of stocking programmes worldwide and to assess the information available to evaluate such programmes. Hatchery Production Statistics provided by Member countries of FAO have only recently become available within FAO. We present these data and make recommendations for further improvement of reporting and monitoring of stocking programmes in marine and coastal environments.

DATA RESOURCES AND DATA PROCESSING

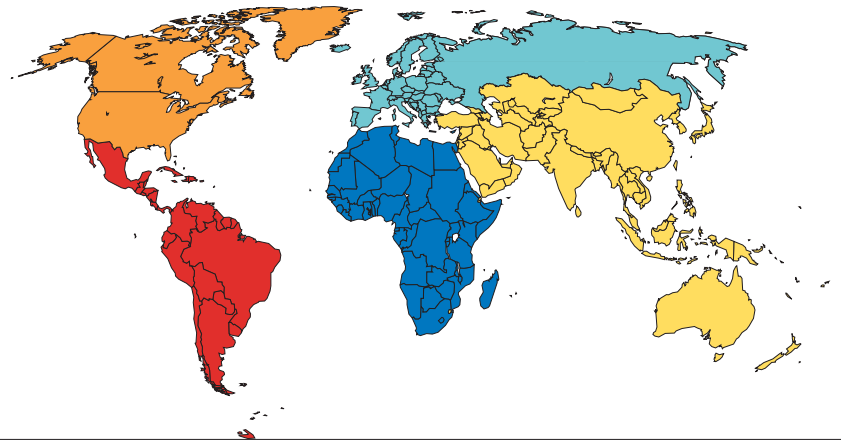
FAO's Hatchery Production Data are provided by its Members on the basis of a questionnaire issued by the FAO Fisheries Statistical Division. These data have recently been compiled and organized by A. Immink. The data are segregated by species (including various life-stages), country, year and release environment (into controlled environments – i.e. for aquaculture, or into the wild – i.e. for stock enhancement) and cover the period 1984–1997. Production figures are mostly given in numbers. For the purpose of this contribution, releases into the wild were analysed excluding releases for aquaculture purposes. Data from landlocked countries were excluded.

As a second source of information literature in the Aquatic Sciences and Fisheries Abstracts (ASFA) was used. This database was searched for information on stock enhancement (stocking, ranching) in marine and brackish water environments. The selected references (1 173 in total) were organized in a spreadsheet and a list of species appearing in the references was prepared. First selection of references was based on this species list. Only the species that spend at least a part of their lifecycle in marine environments were included. Species confined to brackish-fresh (for example tilapia) and freshwaters were excluded and a part of the species that live in all three environments were excluded: (i) if never used for aquaculture in marine/brackish environments according to the FAO Aquaculture Statistics 1987–1996 (FAO, 1998): *Thymallus thymallus*, *Plecoglossus altevilus* and *Salvelinus fontinalis*; (ii) if known to be stocked in freshwater from scientific literature: *Coregonus peled* (reservoirs species). Information about species and their environment was taken from the FAO Database on Introductions of Aquatic Species and FishBase (Froese and Pauly, 1998). A list of species used in the analysis is given in Appendix 1. A total of 158 ASFA references were found relevant to marine and coastal stock enhancement.

TABLE 1. Countries reporting marine stocking by region

Region	Total number of countries reporting marine stocking	Number of countries reporting hatchery production to the FAO	Number of countries reporting stocking in the literature and ASFA
Europe	19	16	11
Asia and Oceania	23	19	7
Africa	9	9	0
North America	2	1	2
Latin America	11	11	0
All	64	56	20

FIGURE 2. Definitions of regions



GEOGRAPHIC COVERAGE OF MARINE STOCK ENHANCEMENT INFORMATION

Fifty six countries reported marine hatchery releases to FAO between 1984 and 1997. Additionally, eight more countries reported stocking practices and research in scientific literature only. Worldwide, 64 countries reported some activity in marine and coastal stocking, ranging from experimental research or large scale industrial releases as shown in Figure 1.

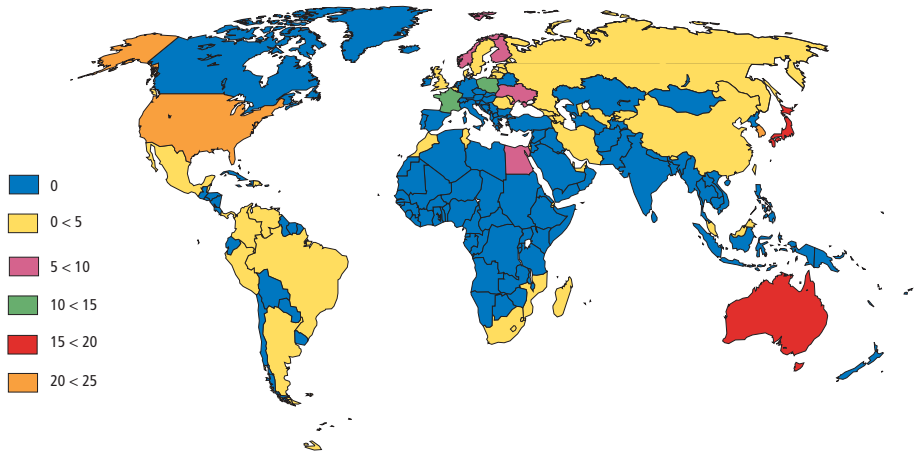
Marine stocking practices are not equally represented among regions as can be seen in Table 1 (for definition of the regions see Figure 2). Africa and Latin America do not have any relevant stocking examples in the ASFA literature, although stocking is practised in these regions as reported by hatchery production. In general, countries in developed regions (Europe, North America) contribute more scientific information to ASFA. Information in the less developed regions is probably more abundant in grey literature (project reports). In conclusion, many countries thatO have marine stocking programmes do not report these in scientific literature. Efforts should be made to explore information in unpublished reports and grey literature to obtain information for these countries.

To get a more balanced picture of the extent of marine stocking in the various regions, the countries that reported stocking are expressed as a percentage of all countries that are connected to marine environments including the Caspian and Black seas (i.e. excluding landlocked countries). Europe and North America have relatively the highest number of countries that reported marine stocking; Africa and Latin America show a lower effort with an intermediate position for Asia and Oceania. Worldwide, about one third of all countries with a connection to the sea report stock enhancement (Table 2).

TABLE 2. Relative importance of marine stocking by region

Region	Countries reporting marine stocking (A)	Countries with sea connection (B)	A/B
Europe	19	35	0.54
Asia and Oceania	23	61	0.38
Africa	9	41	0.22
North America	2	4	0.50
Latin America	11	42	0.26
All	64	183	0.35

FIGURE 3. Number of species reported to FAO as released into the wild



The number of species produced in hatcheries for release into marine and coastal environments as reported to FAO is given in Figure 3. More than ten different marine and coastal species are stocked in the United States, Republic of Korea (North Korea), Australia, Japan, Spain and Poland. For some countries the numbers are lower than we know from scientific literature. For example, in Japan over 80 species are reported to be reared for stock enhancement (Masuda and Tsukamoto, 1998) and various species are stocked in Canada despite the absence of hatchery production data for this country. However, the production figures give additional information about countries and species that are not reported in scientific literature. For example, Republic of Korea reports marine stocking of 21 species, but no accounts were found in the scientific literature. This information can be useful for further studies into the feasibility of marine stocking programmes.

Species that are stocked in two or more different countries are presented in Table 3. Species are divided into three groups: marine, marine-brackish and marine-brackish-fresh. In the first two groups, geographical distribution is limited to a maximum of four reporting countries. In the third group, rainbow trout, sea trout and Atlantic salmon are relatively widespread. It should however be noted that rainbow trout in many cases is stocked in freshwater environments and that the countries that practise stocking of sea going rainbow trout are probably overestimated. Sea trout and Atlantic salmon are species used for marine ranching with a large geographic range worldwide. In conclusion, species used in marine stocking are generally not widespread, except for some salmonids.

White seabass, lobsters and cod are reportedly stocked in only one/no country, e.g. cod in Norway, white seabass not reported. We have only included in Table 3 species that are stocked in at least two countries according to hatchery production data to prevent this table form being overly extensive. Table 3 could have been extended using information from the ASFA, but it is mainly to show that the species used for marine stocking are not widespread but only locally released except for salmonids. This is also why some species in Table 3 are different from those in Table 4. In the latter they are ranked according to production, in the former according to the number of countries in which they are stocked.

TABLE 3. Species reported to be stocked in two or more countries

Marine, 34 total	Common name	Countries
Strombus gigas	Queen conch	3
Pagrus major	Red seabream	3
Trochus niloticus	Topshell	2
Mithrax spinosissimus		2
Tridacna derasa	Giant clam	2
Paralichthys olivaceus	Japanese flounder	2
Puntazo puntazo		2
Marine–brackish, 24 total		
Penaeus monodon	Giant tiger prawn	4
Penaeus japonicus	Kuruma prawn	3
Sparus auratus	Gilthead seabream	2
Penaeus merguiensis	Banana prawn	2
Marine–brackish–fresh, 43 total		
Oncorhynchus mykiss	Raibow trout/steelhead	26
Salmo trutta	Sea trout	19
Salmo salar	Atlantic salmon	14
Coregonus lavaretus	Whitefish	7
Acipenser spp.	Sturgeons	7
Lates calcarifer	Barramundi	6
Salvelinus alpinus	Arctic char	5
Oncorhynchus kisutch	Coho salmon	4
Oncorhynchus tshawytscha	Chinook salmon	4
Oncorhynchus keta	Chum salmon	3
Coregonus spp.	Whitefish	3
Dicentrarchus labrax	European seabass	3
Oncorhynchus gorbuscha	Pink salmon	2
Plectroplites ambiguous		2
Mugil spp.	Mullets	2
Oncorhynchus masou	Masou salmon	2
Lampetrafluviatilis		2
Mugil cephalus	Grey mullet	2
Salvelinus spp.	Chars	2

Source: FAO hatchery production statistics.

In terms of production (numbers produced) the major stocked species are listed in Table 4. Japan and Republic of Korea produce various marine and brackish species such as Ezo scallop (*Patinopecten yessoensis*), Red seabream (*Pagrus major*), Japanese flounder (*Paralichthys olivaceus*) and Black porgi (*Acanthopagrus schlegeli*) in large quantities. Furthermore, Queen conch (*Strombus gigas*) is produced on a large scale in the Caribbean as well as Giant clam (*Tridacna maxima*) in Tonga. Various shrimps, scallop and the oyster *Crassostrea gigas* are released into marine-brackish environments. Of the species occurring in all environments, the salmonids (*Oncorhynchus* spp., *Salmo* spp.) and coregonids are extensively produced for stocking.

Table 4 indicates a large variation in the number of years for which data were reported for stocked species. For example stocking data from several years exist for

the crab *Portunus trituberculatus*, Black rockfish (*Sebastes schlegeli*), and black porgy (*Oplegnatus faciatus*) from Republic of Korea and Japan and for salmonids and striped bass in the United States. Many species are however reported sporadically as illustrated in Figure 4. The number of species and countries with data for more than seven years are shown in Table 5 (38 species). The data indicate that for various salmonids, striped bass (*Morone saxatilis*), red seabream, Japanese flounder and the shrimp *Penaeus orientalis kishimouye* long-term enhancement programmes are carried out. However, the number of species with long data series is limited, indicating that many stocking programmes have been experimental rather than industrial and that data were not provided consistently to FAO.

TABLE 4. Major species in terms of hatchery production for release into natural environments

Species	Total no. produced between 1984 and 1997	Average no. of years reported	No. of countries	Countries
Marine				
Patinopecten yessoensis	5 656 216 000	3	1	Japan
Pagrus major, Acanthopgrus schlegeli, Ebynnis japonica	105 019 000	2	1	Japan
Paralichthys olivaceus	55 878 000	2	1	Japan
Tridacna maxima	25 020 000	2	1	Tonga
Penaeus vannamei, P. stylirostris	22 500 000	1	1	Panama
Pagrus major	14 230 000	3	3	Japan, Republic of Korea, Taiwan Province of China
Seriola quinqueradiata, S. aureovitlata, S. dumerili	13 963 000	3	1	Japan
Portunus trituberculatus	9 361 000	7	1	Republic of Korea
Strombus gigas	5 700 000	1	3	Belize, Sao Tome, Turks & Caicos Islands
Paralichthys olivaceus	3 593 000	5	2	Japan, Republic of Korea
Sebastes schlegeli	2 739 000	7	1	Republic of Korea
Acanthopagrus schlegeli	1 009 000	9	1	Republic of Korea
Haliotis diversicolor aguatilis	889 000	2	1	Taiwan Province of China
Oplegnathus fasciatus	613 000	6	1	Republic of Korea
Marine-brackish				
Penaeus (orientalis) chinensis	1 370 000 000	1	1	China
Penaeus japonicus	366 327 501	3	4	Japan, Republic of Korea, Portugal, Taiwan Province of China
Scallop	165 937 000	3	1	USSR
Crassostrea gigas	160 140 000	3	1	Japan
Penaeus orentalis kishimouye	106 655 000	8	1	Republic of Korea
Penaeus monodon	26 316 000	1	5	Brunei, Republic of Korea, Mauritius, Seychelles
Penaeus merguiensis	16 925 800	1	1	Malaysia
Mugil incillis	15 468 000	3	1	Colombia
Sciaenops ocellatus	141 00 045	3	1	USA
Sparus auratus	7 620 000	1	3	Cyprus, Egypt, Portugal
Penaeus stylirostris	1 500 000	1	1	Panama
Sparus auratus, Dicentrarchus labrax	950 000	1	1	Cyprus

Table continues overleaf

TABLE 4. Major species in terms of hatchery production for release into natural environments *(continued)*

Species	Total no. produced between 1984 and 1997	Average no. of years reported	No. of countries	Countries
Marine-brackish fresh				
Coregonus spp.	18 522 918 000	4	6	Finland, France, Russian Federation
Oncorhynchus gorbuscha	8 523 667 135	7	2	Chile, USA
Oncorhynchus keta	3 961 456 987	9	3	Chile, USA, Republic of Korea
Oncorhynchus mykiss	3 787 792 804	4	42	France, USA, South Africa, Finland, Iran, etc.
Salmo trutta	3 523 832 192	5	25	France, USA, Finland, Poland, etc
Oncorhynchus tshawytscha	1 543 758 158	6	4	Australia, New Zealand, USA, Chile
Oncorhynchus nerka	1 489 348 103	14	1	USA
Acipenser spp.	1 016 164 800	4	7	Azerbaijan, Iran, Ukraine, Russian Federation, Georgia, France
Oncorhynchus kisutch	568 460 018	5	4	Chile, Cyprus, USA, France
Mugil cephalus, Liza ramada	526 500 000	6	1	Egypt
Salmo salar	337 348 663	5	25	Norway, USA, Finland, Iceland, Sweden, etc.
Coregonus lavaretus	146 405 400	2	7	Estonia, Finland, Lithuania, Poland
Oncorhynchus spp.	137 446 735	2	1	USA
Morone saxatilis	125 937 206	14	1	USA

Source: FAO hatchery production statistics.

Tables 3 and 4 are based on the FAO hatchery production statistics. As shown in Table 6, some known released species are not reported to FAO, because (i) reports of member countries are incomplete; (ii) private sector and pilot-scale stocking efforts are not included because data are based on official government information. It should be noted that Table 6 does not include the many species stocked in Japan.

Note: Rainbow trout (*O. mykiss*) and other salmonids are stocked in fresh, brackish and marine environments. The data do not provide information about the release environment and may therefore be biased for these species.

FIGURE 4. Number of reported years per species

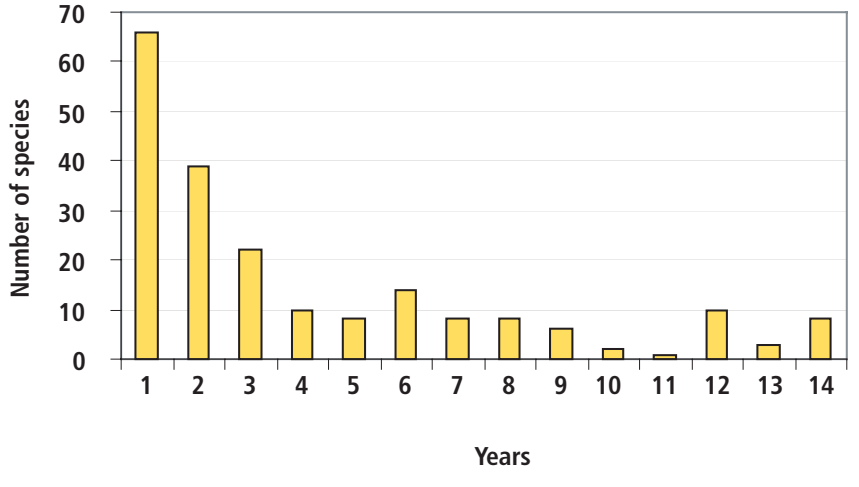


TABLE 5. Countries and species with long-term records (8–14 years) in the Hatchery Production Statistics

Country	Species
USA	*Morone saxatilis, Oncorhynchus clarki, O. gorbusha, O. keta, O. kisutch, O. mykiss, O. nerka, O. tshawytscha, S. salar, S. trutta, Acipenser brevirostrum*
Finland	*O. mykiss, Salmo salar, S. trutta*
Republic of Korea	*O. keta, Acanthopagrus schlegeli, Pagrus major, Paralichthys olivaceus, Penaeus orientalis kishimouye*
Latvia	*S. salar, S. trutta, O. mykiss*
Morocco	*O. mykiss, S. trutta*
Sweden	*S. salar, S. trutta*
France	*S. trutta, S. salar*
Iceland	*S. salar*
Georgia	*S. trutta*
Colombia	*O. mykiss*
Belgium	*O. mykiss*
Cyprus	*O. mykiss*

Note: Rainbow trout (*O. mykiss*) and other salmonids are stocked in fresh, brackish and marine environments. The data do not provide information about the release environment and may therefore be biased for these species.

TABLE 6. Stocked species not present in the Hatchery Production Statistics

Species	Common name	Countries	Remark
Alosa sapidissima	American shad	USA (Pennsylvania)	
Anadara broughtonii	Arkshell	Japan	
Atractoscion nobilis	White seabass	USA (California)	
Centropomus undecimalis	Common snook	USA (Florida)	
Chelonia mydas	Green sea turtle	Philippines	
Coryphaena hippurus	Common dolphinfish	Hawaii	Proposed
Gadus macrocephalus	Pacific cod	USA (Puget Sound), Japan	
Haiotis discus hannai	Ezo abalone	Japan	
Homarus americanus	Lobster	USA	
Homarus gammarus	Lobster	Norway, UK, USA (Maine)	
Lepidochelys kempi	Kemp's ridley turtle	USA	
Mercenaria mercenaria	Hard clam	USA (North Carolina, New York)	
Ophiodon elongatus	Ling cod	USA	Proposed
Panope abrupta	Geoduck clam	USA	
Paralichthys californicus	California halibut	USA (California)	
Pecten novaezelandiae	Scallop	New Zealand	
Platichthys flesus	Flounder	Denmark, Netherlands (1977)	
Pleuronectes platessa	Plaice	Denmark, Netherlands (1977)	
Polydactylus sexfilis	Pacific treadfin	Hawaii	
Portunus trituberculatus	Crab	Japan	
Pseudocaranx dentex	Striped jack	Japan	Proposed
Scophthalmus maximus	Turbot	Denmark	
Sparus aurata	Gilthead seabream	Tunisia (lagoons)	
Takifugu rubripes	Tiger puffer	Japan	Probably

An overall table with stocked species, the countries and source of information is given in Appendix 1 for further reference. We found 119 different species stocked for marine enhancement, of which 26 were in Japan. Assuming that another 60 species that are not included in the list are stocked in Japan (a total of 80 or more species for marine stocking in Japan), we arrive at a total of 180 species that have been stocked for marine and coastal enhancement. For some of these it is difficult to know the exact release environment and the list may therefore include species-country combinations that belong to inland stocking. Further analysis and improvement of this preliminary analysis will exclude these combinations. According to Moksness and Stoele (1997), in the Pacific, more than 30 fish species have been identified as part of a future sea ranching programme, and in the Atlantic fewer than ten. We have listed considerably more species, probably because we included not only the genuine marine and brackish species but also species that can be stocked from fresh to saline waters. If we only include those confined to marine environments, we find a total of 46 species that have been used for sea ranching.

THE NEED FOR STANDARDIZED NOMENCLATURE AND REPORTING FORMAT

With nearly 70 countries stocking approximately 180 species, it is clear that stocking projects represent a significant global activity in managing marine and coastal fisheries. Fishery managers and international development organizations have high expectations for stocking programmes:

- "Sea ranching provides one of the best possibilities for greatly increasing some fish and shellfish production..." – International Center for Living Aquatic Resources Management (ICLARM) press release, 1995.
- Kyoto Plan of Action calls for "...rapid transfer of technology and know-how in enhancement of inland and marine waters" – FAO/Japan Kyoto Conference, 1995.
- "Explore the potential ... to enhance ... fisheries ... through stock enhancement." – Australia's National Policy on Aquaculture.

On the other hand, serious concerns have been raised about the usefulness of marine stocking and its possible negative impacts on native fauna.

Not all scientists feel that stocking is an appropriate management option for fisheries management and many fishery managers realize that stocking alone will not be an effective means to manage fisheries:

- "Enhancement measures should be evaluated against other management measures… not only in terms of costs, productivity and catches but more importantly in relation to sustainability." (Kirkegaard, 1997);
- "Do not use artificial propagation as a substitute for precautionary measures…" (FAO, 1995b).
- "History has shown that a hatchery program can generate a broad base of public and political support in the total absence of any objective evidence that it actually works" (MacCall, 1989), but perhaps the title of Dr MacCall's paper is more telling: "Against marine fish hatcheries: ironies of fishery politics in the technological era".

The first prerequisite for objective evaluation of the pros and cons of stock enhnancement is a sound information base including accurate information on the effectiveness and cost-effectiveness of stocking programmes to allow policy makers, fishery managers and conservationists to make informed decisions. In this respect, Article 9.2.4 of the FAO Code of Conduct for Responsible Fisheries calls on countries

to "… establish appropriate mechanisms, such as databases and information networks to collect, share and disseminate data in order to have a responsible development of aquaculture, including culture-based fisheries in areas under national jurisdiction… (and) within transboundary aquatic ecosystems." (Article 9 FAO, 1995). Technical guidelines have been created to help implement the Code.

Unfortunateley, in practice it seems difficult to obtain accurate information on stock enhancement operations. The European Union is conducting a project, "Analysis of the environmental and economic impact of operations to reinforce the aquatic fauna of fresh waters for fishery purposes" which is essentially an evaluation of inland stocking programmes. It has been difficult to obtain accurate data on the scale and success of these operations (Ian Cowx, personal communication). If accurate data on inland stocking in Europe are difficult to obtain, gathering data on marine stocking in less developed areas would be expected to be even more problematic.

Currently, information on stocking and the results of stocking are scattered among government offices/publications, grey literature and academia and scientific literature. There is a need for stakeholders to work together to gather this information in an accessible format. The following suggestions are offered to move toward improving information in order to achieve more responsible stocking programmes.

- Improve reporting forms, e.g. FAO country questionnaires, and standardize terms;
- scientists and government resource/hatchery managers should work together to gather information and present it in an user-friendly format, this should include extracting existing data from grey literature;
- establish monitoring systems to judge accurately the cost/benefit (in monetary and non–monetary terms) of stocking programmes;
- promote awareness of the issues and controversies associated with stocking so that appropriate data can be gathered and disseminated to appropriate stakeholders;
- include stocking of inland waters and identify commonalities and differences between stocking inland and marine and coastal areas.

FAO is currently improving the collection of its hatchery production data. Although FAO has requested hatchery data from countries since it began collecting aquaculture data in 1984, the data have never been processed because of a lack of immediate interest from member countries. Over time this has led to gaps in the data some of which are now quite large (Figure 4, Appendix 1). FAO hopes, in collaboration with national governments, to collate these non-reported data so that a more complete record is compiled. The FAO aquaculture questionnaire (on which these data are collected) is currently undergoing a process of revision, which should give clearer definitions and instructions for completion of the form. It is hoped that this new form, to be compiled in conjunction with national statistical agencies, will improve data submission. A public hatchery database is still some years away, but in the meantime we will strive to make current data collection more consistent. Hatchery data are important for governments to assess the efficiency of aquaculture production systems (what goes in should come out) and also to assess stocking programmes, not just for efficiency, but also for stock quality and sustainability.

It is our hope that the database presented here and groups of interested stakeholders, such as the WAS working group on Responsible Stock Enhancement, will help promote responsible stocking and implement elements of the Code of Conduct for Responsible Fisheries.

References

Bartley, D.M. 1996. Conservation of biological diversity in hatchery enhancement programmes. *In* di F. Castri & T. Younés, eds. *Biodiversity, science and development: towards a new partnership*, pp. 424–438. Wallingford, UK, CAB International.

FAO. 1995a. *Code of conduct for responsible fisheries*. FAO, Rome.

FAO. 1995b. *Precautionary approach to fisheries. Part 1: guidelines on the precautionary approach to capture fisheries and species introductions*. FAO Fisheries Technical Paper 350/1. FAO, Rome.

FAO. 1998. *Aquaculture production statistics 1987–1996*. FAO Fisheries Circular No. 815, Rev. 10. FAO, Rome. 197 pp.

Froese, R. & Pauly, D., eds. 1998. *FishBase 98: concepts, design and data sources*. With two CD-ROMs. ICLARM, Manila.

Kirkegaard, E. 1997. *Stock enhancement and sea ranching as an alternative to traditional management*. Paper presented at the First International Symposium on Stock Enhancement and Sea Ranching, Bergen Norway, 8–11 September 1997.

MacCall, A.D. 1989. Against marine fish hatcheries: ironies of fishery politics in the technological era. *Cal. COFI Reports*, 30: 46–48.

Masuda, R. & Tsukamoto, K. 1998.Stock enhancement in Japan: review and perspective. *Bull. Mar. Sci.*, 62: 337–358.

McCarty, C.E., McEachron, L.W. & Rutledge,W.P. 1993. *Beneficial uses of marine fish hatcheries: the Texas experience*. The International Symposium on Sea Ranching of Cod and Other Marine Species, Arendal, Norway, 15–18 June 1993. Programme and Abstracts. 54 pp.

Moksness, E. & Stoele, R. 1997. Larviculture of marine fish for sea ranching purposes: is it profitable? *Aquaculture*, 155(1–4): 345–357.