FORECAST OF YIELDS

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Keywords: fisheries, sustainable fisheries, development trends, shelf area, maximum sustainable yield, marine fisheries

Contents

Summary

This chapter compiles various studies made by the FAO Fisheries Department, providing tools and methods for fisheries management and future production forecasting. The use of GIS to provide estimates of shelf area production is proposed and comparative figures are given of the different FAO Fishing Areas. A synthetic analysis of fisheries production growth over an extended period of time (1950 to 1994) is given. This includes the description of a generalized fishery development model where the fishery status presents four consecutive phases: undeveloped, developing, mature, and senescent. It is concluded that based on analyses of 200 major fishery resources, 60% are presently (at the beginning of the new millennium) either mature or senescent, and that given that few countries have established effective control of fishing capacity, these resources are in urgent need of management action to halt the increase in fishing capacity or to rehabilitate damaged resources. The consequences of El Niño phenomena for fisheries are also discussed. Finally, a list of possible solutions is

provided to ensure fishery sustainability that should be implemented at international, national and local levels.

1. Introduction

This chapter is based on information gathered from the FAO publications “Review of the State of World Fishery Resources: Marine Fisheries” and papers presented at the Second World Fisheries Congress (Australia, 1996). These reviews provide information on fish production over an extended time series (1950-1994) and contain interesting findings and general conceptual postulates regarding the general trends and potential of fisheries at global and regional scales.

The article considers:

- fisheries trends by estimates of production per shelf area,
- a review of fisheries growth trends and potential for future fisheries, and
- a framework for sustainable fisheries.

2. A Perspective on Fisheries Trends Offered by Estimates of Production per Shelf Area

The growing use of Geographical Information Systems (GIS) technology and databases has allowed estimates of shelf area to be made for FAO Fishing Areas for statistical purposes (see *World Yields of Marine Organisms*). Fishery production figures, otherwise expressed in terms of landings can, therefore, be made more easily comparable by expressing them, as for agricultural and forestry resources, per surface area available for their production. When landings of shelf-dependent resources (bottom fish and invertebrates) and small- and medium-sized pelagic fish (living resources associated with, but not restricted to, shelf waters) are each expressed per surface area of continental shelf within the 200 m depth by individual FAO Fishing Areas (Tables 1 and 2), certain surprising regularities emerge. At least half of the marine statistical areas realized peak production figures at some time previous to the last five-year period of 1990–94 (especially for areas in the northern hemisphere), and these peak values show marked similarities within given ranges of latitudes. It is also possible to compare in this way peak production values between areas subject to different climatic and oceanographic conditions.

FAO Area	Oceanic Region	Shelf-dependent	North temperate	South temperate	Tropical	Ranking
47	SE Atlantic	4.629		XXX		1
61	NW Pacific	3.284	XXX			2
21	NW Atlantic	2.471	XXX			3
27	NE Atlantic	2.346	XXX			4
67	NE Pacific	2.036	XXX			5
81	SW Pacific	1.53		(XXX)		6
87	SE Pacific	1.445		(XXX)		7

41	SW Atlantic	0.982		(XXX)		8
51	W. Indian Ocean	0.852			(XXX)	9
77	EC Pacific	0.738			XXX	10
37	Mediterranean	0.704	(???-------	------------	???)	11
57	E. Indian Ocean	0.65			(XXX)	12
34	EC Atlantic	0.642			XXX	13
31	WC Atlantic	0.578			XXX	14
71	WC Pacific	0.444			(XXX)	15
	MEAN RANKING		3.5	5.75	11.8	

XXX indicates under which latitudinal range (north, south temperate and tropical) each FAO Statistical Areas and its associated continental shelf falls.
( ) means the same thing as above but it indicates that catch statistics were computed from the last five years period available at the date of publication.
(???----------???) indicates an unclear or not defined classification based on its latitude range

Table 1. Estimates of production per shelf area (expressed in t km^{-2}).

Statistical Area	**5-yr averages, 1995 to 1994**							
	55-59	**60-64**	**65-69**	**70-74**	**75-79**	**80-84**	**85-89**	**90-94**
47 SE Atlantic			4.629					
			4.569					
21 NW Atlantic			2.471					
				1.09				
27 NE Atlantic						2.346		
					2.103			
31 WC Atlantic						0.578		
						0.744		
34 EC Atlantic					0.642			
							3.746	
67 NE Pacific							2.036	
		0.209						
61 NW Pacific							3.284	
							2.965	
77 E. Central Pacific							0.738	
							1.543	
37 Mediterranean and Black Sea								0.704
						1.808		
41 SW Atlantic								0.982
				0.161				
81 SW Pacific								1.53
							0.371	
87 SE Pacific								1.445

								25.046
71 W. Central Pacific								0.444
								0.516
51 W. Indian Ocean								0.852
								0.669
57 E. Indian Ocean								0.65
								0.59

shelf-dependent species
shelf-associated species

Table 2. Estimates of peak production per shelf area (expressed in t km^{-2}), 1955–1994.

As far as shelf resources are concerned, there is a marked similarity in peak production per shelf area between Fishing Areas in the northern hemisphere, where former peak production levels clustered around 2.7 t km^{-2}, and comparable arcto-boreal areas in the southern hemisphere, where peak levels were lower at some 2.15 t km^{-2}. The exception to this pattern was the Southeast Atlantic, where peak levels were much higher during intensive exploitation by distant water fleets in the 1960s and 1970s.

Fishing Areas which lie in the tropics also show a similar clustering of production figures, with peak production levels for shelf resources that are much lower, at some 0.74 t km^{-2}. Similar figures were obtained for the Mediterranean (0.70 t km^{-2} in 1990–1994). Obviously, there are "hot spots" within each area where local production levels are much higher, such as estuaries and coral reefs, but the average productivity over the whole shelf appears more to reflect natural restraints due to nutrient supply, especially once fishing effort has exceeded optimal levels.

The role of nutrient supply seems to be most evident with respect to pelagic resources, where peak production figures vary from 0.5 t km^{-2} for areas with stratified, nutrient-poor water masses to as high as 25 t km^{-2} in the Southeast Pacific, where the most important upwelling-driven pelagic fishery in the world occurs. Peak pelagic productivity is clearly associated with upwellings in the tropics and sub-tropics but, interestingly enough, upwelling systems are not especially conducive to high production of shelf invertebrates and bottom fish, probably because of environmental instability and the low oxygen conditions that strong upwellings occasionally lead to. In cold-temperate seas, high pelagic production is associated with tidal mixing of nutrient-poor surface and nutrient-rich bottom waters, especially on the extensive continental shelves of the northern hemisphere.

There are tropical areas (such as the Western Indian Ocean) where significant increases in production of tunas and mesopelagic fish may be realizable given strong upwellings, but for most other tropical areas, other than those with locally high production areas associated with coral reefs and estuaries, further increases in production are constrained by nutrient supply. Such nutrient supply is generally poor in stratified tropical waters, and fishery productivity usually drops off rapidly with depth. Here, despite a relatively short history of intensive fishing, there appears to be limited future potential for further increases in production per shelf area, and if there such a potential, it seems likely that this will come from further exploitation of small pelagic resources and tuna.

3. Development Trends and Potential

During the period considered by the first estimate of world potential production based on analysis of historical landings made in the early 1970s (see *World Yields of Marine Organisms*), landings were increasing at about 6% per year (Figure 1), and the potential for traditionally exploited marine species was estimated at about 100 million tonnes per year. This estimate of fishery potential was consistent with estimates made earlier in the late 1960s. In fact, the growth rate for marine production observed by FAO soon fell, although some growth was maintained. Despite fisheries developing based on non-traditional species, marine fishery production has so far only reached about 90 million tonnes (in 1994) with capture fisheries accounting for 84 million tonnes.

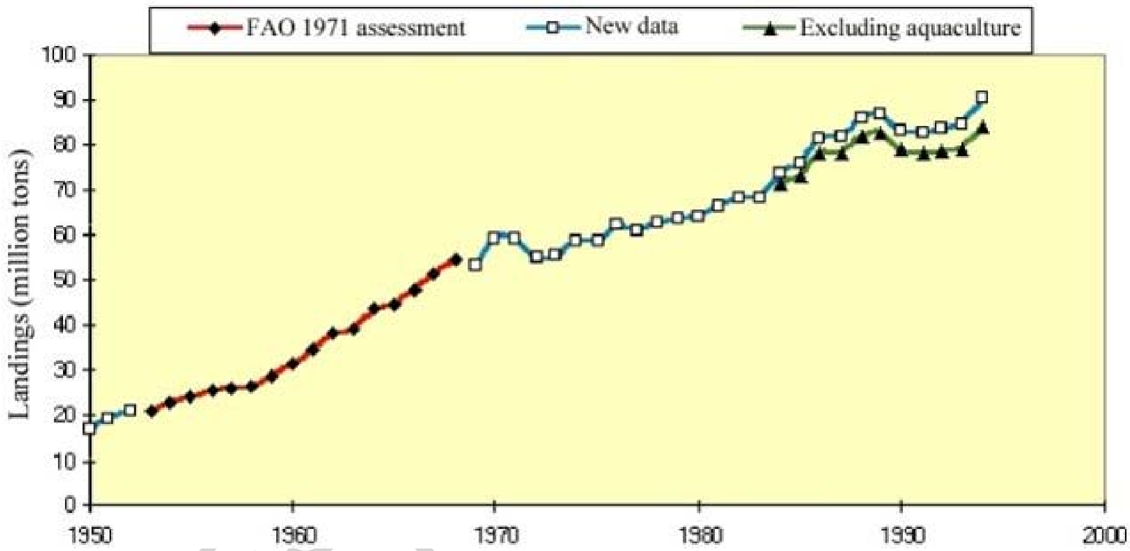

Figure 1. Marine fishery production since 1950.

The following two sections discuss a recent study of fishery development trends and fisheries potential based on an analysis of FAO landing statistics for the period 1950–1994.

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Biographical Sketches

Catherine Aliaume (born France, 1962) obtained a Diploma of Water Techniques and Sciences (major in Hydrobiology) in 1985 at Montpellier University, France, and a Ph.D. in Biomathematics at the University of Paris in 1990 (on the spatial and temporal structure of fish communities in relation to environmental factors). She then went to North Carolina State University in a postgraduate program at the Department of Zoology, and was appointed Research Associate at that university, where she became project coordinator of a 4-year project dealing with game fish population assessment in tropical coastal zones, in collaboration with the Department of Natural Resources. She became an assistant professor in the University of Montpellier in 1995. Her research activities focus on fish bioecology and stock assessment: recruitment, colonization, growth and survival modeling, in relation to environmental factors. Her teaching fields include quantitative data analysis, ecological and biological modeling. She is currently involved in a research program on the adaptive response of fish populations and communities under environmental (climatic or anthropogenic) stress, in collaboration with the Institute of Research for Development (IRD).

Dr. Serge Michel Garcia is a French scientist born in 1945, in Algeria. He holds a Doctorate in Science of the University of Marseille (France, 1976). He started his scientific career studying the biology, dynamics, fisheries and management of penaeid shrimps in Côte d'Ivoire (1968–1975) as a member of staff of the Institute of Research for Development (IRD). In Senegal (1976-1979), he worked as a specialist of shrimp and tropical demersal fisheries, as Demersal Fisheries Program leader, Director of the National Oceanographic Research Centre and Head of the Department of Oceanography. He joined the FAO Fisheries Department in 1979 as responsible for West African fisheries research and management. He headed the Marine Resources Service of this Department from 1984 to 1990, and since 1990 has been Director of the Fisheries Resources Division, in charge of marine and inland fishery resources as well as aquaculture. He is a member of the ICLARM Board of Trustees.

Dr Richard Grainger is Chief of the Fishery Information, Data and Statistics Unit (FIDI) of FAO. An Irish national, he graduated in natural science from Trinity College, Dublin (Irish Republic). He obtained a postgraduate degree in Computation in the Life Sciences from the University of York, England, and a doctorate in fisheries oceanography from University College, Galway (Irish Republic). From 1977 to 1989, he worked as a Fisheries Scientist at the Irish Fisheries Research Centre on ichthyoplankton research, and later took charge of stock assessment for demersal fish. He was a member or chairman of several stock assessment working groups of the International Council for the Exploration of the Sea (ICES), a member of the ICES Advisory Committee on Fishery Management, and a member of the EC Scientific and Technical Committee on Fisheries. He joined the ICES Secretariat in Copenhagen, Denmark as Fishery Secretary in 1989, where he was responsible for the work of the Secretariat related to fisheries. This included providing support to about 20 stock assessment working groups, acting as Secretary to the Advisory Committee on Fishery Management and transmitting advice to three fishery commissions, the EC and ICES member countries. He joined FAO in 1992 as Senior Fishery Statistician in FIDI where he was responsible for the fishery statistics program of FAO and Secretary to the inter-agency Coordinating Working Party on Fishery Statistics (CWP) and the Joint Working Party on Fishery Statistics and Economics (JWP) of the Asia-Pacific Fishery Commission. He served on the editorial board for the Elsevier journal Fisheries Research from 1993 to 1996. He left this post in 1998 when he was appointed Chief of FIDI.

Thang Do Chi obtained his Ph.D. in Natural Sciences at Montpellier II University, France. He is currently Professor and Head of the Lagoon Ecosystems Joint Research Laboratory (CNRS and University Montpellier II). He worked for FAO as Fishery Resources Officer in the Marine Resources Service of the Fishery Resources Department from 1991 to 1996. His terms of reference were to follow the state of marine resources, with special emphasis on West African marine fisheries and to provide technical backstopping as scientific Secretary to the FAO Fishery Committee for the Eastern Central Atlantic (CECAF) and its working parties on resources, especially the CECAF Working Party on Resources Evaluation and the CECAF *ad hoc* Working Groups on Stocks Assessment. He was also responsible for the development of the GIS for the Fisheries Department. During the period 1979–1987, he was fishery biologist/project manager of the UNDP-FAO project Estimation and Monitoring of Marine Resources based at the Fisheries Research Institute, Casablanca, Morocco. Before his assignment at FAO Fisheries Department, he was Professor at the University of Western Brittany, Brest, and Assistant-Professor at the University Montpellier II. His research topics focused on fisheries biology and ecology, population dynamics and stocks assessment. T. Do Chi was recently involved in the development of applications of geographical information systems to coastal and lagoons fisheries ecosystems.