Report of the Workshop

1. OPENING

Dr Robin Allen, Director of the Inter-American Tropical Commission (IATTC), the organization hosting the Workshop and its Chairman, welcomed the participants.

On behalf of the Food and Agriculture Organization of the United Nations (FAO) and its Project on the Management of Tuna Fishing Capacity, which organized the Workshop, Dr Jacek Majkowski, Convener of the Workshop, thanked the participants for:

- finding funds for their travel to La Jolla; and
- the substantial technical work preparatory to the Workshop, which was done in a very timely manner.

He stated that the FAO and its Project are grateful to the organizations that strongly supported the organization of the Workshop and that provided significant in-kind contributions (see Programme of the Workshop in Appendix I). He expressed particular thanks to:

- the IATTC as the host of the Workshop and its Director and other staff members for making the arrangements for the Workshop; and
- the government of Japan, which is financing the Project that organized the Workshop.

Referring to several substantial objectives of the Workshop (see Programme of the Workshop in Appendix I), Dr Majkowski indicated that he was looking forward to the active participation of all the participants in the Workshop, which would allow these objectives to be fulfilled.

2. INTRODUCTION OF PARTICIPANTS

The Chairman asked the participants of the Workshop to introduce themselves, indicating their institutional affiliations. These are listed in Appendix II.

3. ADOPTION OF THE PROVISIONAL AGENDA

The provisional Agenda (Appendix III) was adopted without any changes. The list of papers to be presented at the Workshop (Appendix IV) was also adopted.

It was decided to include a glossary of terms (Appendix V).

4. LOGISTIC ARRANGEMENTS FOR THE WORKSHOP

The Director of the host organization (IATTC) and Convener of the Workshop presented logistic arrangements for the meeting. The Convener of the Workshop suggested the following rapporteurs

- Jacek Majkowski – Agenda Items 1 to 6
- John Hampton and Victor Restrepo – Agenda Item 7
- Sachiko Tsuji and Chris Reid – Agenda Item 8
- Peter Miyake and Julio Morón – Agenda Item 9
- Pablo Arenas and Gerald Scott – Agenda Items 10 and 11
- William Bayliff and Sachiko Tsuji – Agenda Item 12
- James Joseph and Naozumi Miyabe – Agenda Item 13
- Jacek Majkowski – Agenda Items 14 and 15
- Fabio Carocci and Jacek Majkowski – overall coordination

5. STATEMENT FROM AND REPORT OF THE WORKSHOP: CONTENT AND LOGISTIC ARRANGEMENTS FOR THEIR PREPARATION

Dr Majkowski, Convener of the Workshop, proposed that the participants make suggestions regarding the content of the Statement during the session associated with Agenda Item 11. The participants agreed that it would be useful to present this Statement to the Meeting of Tuna RFMOs and their members to be held in Kobe, Japan, in January 2007.

6. OVERVIEW OF THE PROJECT AND ITS IMPLEMENTATION
Paper 1: Overview of the Project on the Management of Tuna Fishing Capacity and its implementation

Dr Majkowski explained that his presentation was prepared to place the Workshop in the context of the FAO Project on the Management of Tuna Fishing Capacity. He provided basic information on the Project, particularly its objectives and activities, in the form of studies and meetings. Then, he concentrated on the outcome of the previous meeting organized by the Project (Second Meeting of Technical Advisory Committee of the Project on the Management of Tuna Fishing Capacity, referring to:

- Report of the Second Meeting of the Technical Advisory Committee (TAC) GCP/INT/851/JPN, Madrid, Spain, 15-18 March 2004.
- Bayliff, W.H.; Leiva Moreno, J.I. de; Majkowski, J. (eds.). Second Meeting of the Technical Advisory Committee of the FAO Project "Management of Tuna Fishing Capacity: Conservation and Socio-economics". Madrid, Spain, 15-18 March 2004. FAO Fisheries Proceedings. No. 2. Rome, FAO. 2005. 336p.

At the end of his presentation, he recalled the objectives of the Workshop (see Appendix I).

7. DEVELOPMENT OF QUANTITATIVE METHODS TO DETERMINE THE DESIRED CHANGE TO FISHING CAPACITY ON THE BASIS OF THE STATUS OF STOCKS
Paper 2: Estimated target fleet capacity for the tuna fleet in the eastern Pacific Ocean, based on stock assessments of target species

Dr Arenas described how the IATTC has handled the issue of carrying capacity of the tuna fleet in the eastern Pacific Ocean (EPO). A target of 158 000 cubic metres (m³) of carrying capacity has been adopted by the IATTC for the purse-seine fleet. No target carrying capacity has been established for the longline fleet, but catch limits for this gear were established for 2004 through 2006. Factors affecting the fishery and management tradeoffs were discussed. The rationale for the establishment of a target capacity is to keep it at a level that could take the maximum harvest from the fishery, while at the same time ensuring the sustainability of each stock. Historical management measures, assessments and simulation results were reviewed for both gears, with consideration of the multi-gear and multi-species nature of the fishery. It was concluded that the target of 158 000 m³ for the purse-seine fleet is still appropriate (unless species-specific fishing methods, especially for skipjack, can be developed), but the carrying capacity of the purse-seine fleet is now 20 to 25 percent above it. A target effort of 160 million hooks (about the level of 2001-2002) for the longline fleet was suggested. It was concluded that with the current mix of gears, the capacity of both fleets is above the capacity appropriate for the management of the tuna stocks in the EPO.

Paper 3: Estimates of large-scale purse seine, baitboat and longline fishing capacity in the Atlantic: an analysis based on a stock assessment of bigeye tuna

Dr Restrepo described an approach for estimating fishing capacity based on the results of an age-structured stock assessment, using Atlantic bigeye tuna as an example. The approach provided estimates of output capacity and capacity utilization by gear type,

plus estimates of excess capacity based on maximum sustainable yield (MSY). MSY estimates were allowed to vary over time to reflect the observed changes in selectivity for all fisheries combined. The method appeared to be consistent with traditional definitions of fishing capacity in fisheries science and with the technological-economic approach.

Paper 4: A case study of the impact of recent management measures on overall United States Atlantic longline fishing capacity and effort

Dr Scott described a study of recent management actions taken regarding the United States Atlantic pelagic longline fleet and their combined effects on several indicators of fleet effort and capacity for harvesting swordfish. During the period of management over the past decade, the various measures of United States Atlantic pelagic longline fishing effort and capacity have declined. During the past few years, the total catches of United States vessels have been less than the Total Allowable Catches (TACs), based on estimated maximum sustainable yield, for the United States of America, although substantial amounts of dead fish (mostly undersized) have been discarded. Based on information from generalized linear modeling used to standardize the catch rates for stock assessment, the range of relative efficiencies of the different fishing strategies used within the fleet indicates that the capacity of the fleet would be to sufficient to harvest the United States TAC if a greater proportion of the fleet would apply the more efficient fishing strategies already existing within the fleet. Use of information held within similar standardization analyses could be more broadly applied to estimate capacity frontiers among the fleets harvesting tunas and billfishes.

Paper 5: Estimates of large-scale purse-seine and longline fishing capacity in the western and central Pacific based on stock assessments of target species

Dr Hampton outlined the issues related to the estimation and application of capacity measures consistent with stock assessments of tunas in the western and central Pacific Ocean. While it is relatively simple to specify capacity limits consistent with the stock status of various species, there would be a number of difficulties in applying such an approach in practice. First, the multispecies nature of the purse-seine and longline fisheries and the differential stock status of the main species make it difficult, if not impossible, for single gear-specific capacity limits, or, indeed, other broadly-specified effort-based measures, to address equally the stock status of all species simultaneously. Second, the problem of "effort creep" (increases in efficiency of individual vessels, resulting in increased fishing effort without replacing any of the vessels) is significant for capacity and other effort-based management systems. If such measures are employed, it is essential that the limits are regularly reviewed and, if necessary, adjusted downward to counter effort creep. Third, the specification of capacity limits involves, either explicitly or implicitly, an allocation of those limits. Typically, this allocation is based on the current or recent average fleet composition. However, it is shown that altering the mix of gear types, and hence altering the overall size selectivity of the fishery, can produce very different outcomes for stock status and productivity. Therefore, appropriate levels of fishing capacity in one component of the fishery will depend on the fishing capacity of the other components.

General discussion

Link to stock assessment: The Workshop agreed that using an approach to estimate capacity that is based on a stock assessment has several advantages, including:
- using data that are readily available;
- relating to terms that assessment scientists are already familiar with;
- taking into account estimates of stock abundance over time;
- ability to model multiple fisheries simultaneously;

- ability to model changes in fishing efficiency and species targeting over time.

Further development of these methods is encouraged.

The use of stock assessment methods to estimate output-based capacity requires that the definition of fisheries in the stock assessment model be consistent with how the fisheries are defined for the purposes of measuring capacity. For example, tuna stock assessments frequently define fisheries according to set type and area. Such definitions would not be consistent with capacity measurement because purse-seine capacity cannot normally be disaggregated by set type. However, the ability of purse seiners to switch between set types and areas should be incorporated into output-based capacity measures. Data envelopment analysis (DEA) accommodates this by incorporating such variability into the data, which affects the location of the production frontier. While it might be possible to aggregate the assessment results across set types and regions, a better approach when using stock-assessment based approaches for the purpose of capacity estimation might be to re-define the purse-seine fisheries as a single entity, and, as is done in DEA analyses, incorporate the variability in fishing mortality due to set type and area of operation into the data.

Capacity, selectivity and allocation: Several of the papers presented demonstrated that the long-term potential productivity of a stock can be affected by changes in the overall selectivity of the fisheries that exploit it. This is particularly important in cases for which some fisheries capture smaller fish and others capture larger ones, and the relative importance of these fisheries changes over time. Thus, when defining an "appropriate" overall level of capacity for mixed fisheries, there can be different allocation implications, depending on the selectivity pattern that is assumed.

Data and data resolution: In order to utilize output-based measures of capacity (determined either by stock assessment models or methods such as DEA in fisheries management, the output-based measure must be translated into a physical capacity measure, such as vessel numbers or vessel carrying capacity. This requires data on the relationship between fishing effort or catch and the capacity measure.

From the discussion of the papers presented during this and other agenda items, it was apparent that estimates of capacity may be affected by the levels of aggregation in the data. In general, increased aggregation should result in lower estimates of capacity. This generalization is expected to apply to all deterministic methods that attempt to define a "frontier" of maximum output (for example, DEA or the method presented in Paper 3). For this reason, the dependence of estimates of capacity on the level of data aggregation and assumptions should be tested.

8. FEASIBILITY OF (1) ROUTINELY COLLECTING INPUT DATA FOR DATA ENVELOPMENT ANALYSES (DEAS) AND (2) PERFORMING INDUSTRY SURVEYS OF FISHING CAPACITY UTILIZATION
Paper 6: Review of existing information and their potential use for analyses and management of fishing capacity[1]

Dr Tsuji presented an overview of data potentially useful for the management of fishing capacity of tuna fleets. Vessels of about 60 countries take over 95 percent of the global catches of tunas, and most of these participate in regional tuna management schemes. A variety of vessel information has recently become available to the public, but this information must be organized and combined with information on fishing activities and various transactions if they are to be usable for management of fishing capacity. Her paper proposed that restrictions on fishing effort and on catches be combined with restrictions on fishing capacity to manage the fisheries. The management would

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[1] Not reproduced in these Proceedings.

be based on the results of stock assessments, of course, which would take into account transfers of catch quotas among gear types or fleets and other pertinent developments. Successful implementation of fishing capacity management requires strong commitment by the countries involved in tuna fishing, which would share information on tuna vessels and establish mechanisms to detect and to prevent, if possible, new entries to tuna fishing activities, except as replacements for vessels that were no longer fishing for tunas.

Paper-specific discussion: It was noted that the information on vessels that is available to the public is inadequate, and the importance of reliable fleet statistics was re-emphasized. It was further noted that monitoring of vessels on the high seas is of great interest to many different fisheries bodies, and that attempts are underway to establish mechanisms to do that. The importance of coordination between FAO and the regional fisheries management organizations (RFMOs) for development of mechanisms acceptable to both the fishing industry and conservation groups was expressed.

Paper 7: Measurement of the global fishing capacity of large-scale tuna purse seiners[2]

Dr Majkowski mentioned that at the second meeting of the Technical Advisory Committee it was recommended that the estimates of the total number of large-scale purse seiners and their total carrying capacity that were obtained for 2000 by Dr Joseph (2003)[3] be updated. This proved to be more difficult than anticipated because there was no system for routinely collecting information with which to obtain such estimates. Therefore, the estimates for different years are not necessarily comparable. He described the sources of information for the update:

- Atlantic Ocean: mostly information from governmental organizations of France, Spain and Venezuela and, to a lesser extent, the register of tuna vessels of the International Commission for the Conservation of Atlantic Tunas (ICCAT);
- Indian and eastern Pacific Oceans: registers of tuna vessels of the Indian Ocean Tuna Commission (IOTC) and the Inter-American Tropical Tuna Commission (IATTC);
- western and central Pacific Ocean: a study carried out by Gillett and Lewis (2003)[4].

Then, Dr Majkowski presented updates of the estimates of the number of large-scale purse seiners and their carrying capacity, explaining that the Project could not obtain information on purse seiners registered in Ghana. Possibly because of that, the estimated number of purse seiners in the Atlantic Ocean for 2004 was less than that for 2000. For the Indian and eastern Pacific Oceans, the numbers of purse seiners in 2000 and 2004 were very similar. The numbers of purse seiners in the western and central Pacific Ocean were less in 2004 than in 2000, possibly because purse seiners registered in coastal countries of the region that operate only in the exclusive economic zones (EEZs) of those countries were not included in the 2004 data. In addition, the estimates of the carrying capacities of the fleets operating in all oceans appeared to be less in 2004 than in 2000, possibly due to the use of a factor for converting well volume to carrying capacity that was too low. Dr Majkowski concluded that the differences between the estimates obtained for 2000 and 2004 may be indicative of difficulties in estimating carrying capacities, rather than of changes in total capacities.

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[2] Not reproduced in these Proceedings.
[3] Joseph, J. 2003. Managing fishing capacity of the world tuna fleet. *FAO Fisheries Circular*. No. 982: 67 pp. Rome.
[4] Gillett, R & Lewis, A. 2003. A survey of purse-seine fishing capacity in the western and central Pacific Ocean, 1988 to 2003. Gillett, Preston and Associates Inc.

Paper-specific discussion: It was pointed out that the vessel registration data would be useless unless registration was mandatory and utilized to control fishing capacity, which also emphasized the need to bring all data collected by various organizations into a global database. Clarification was sought on several existing conversion factors from tonnes to cubic metres, and it was explained that the factor of 1.17 (tonnes x 1.17 = cubic metres) was originally developed from U.S. shipyard data about 20 years ago, and that more recent information indicated that a higher factor, perhaps 1.4, would be more appropriate for the eastern Pacific Ocean. With respect to the problems in obtaining registration data for small vessels, it was noted that only a few of these operated only within the EEZs of the countries in which they were registered, and that when small vessels operated in the EEZs of other countries information on them was generally provided to those countries. It was affirmed that this problem was most prevalent in the Philippines and Indonesia.

Paper 8: Measuring fishing capacity in tuna fisheries: data envelopment analysis, industry surveys and data collection

Dr Reid provided an overview of data envelopment analysis (DEA) and data requirements for conducting it. He stated that there must be at least some degree of disaggregation from the fishery level on fixed inputs (vessel characteristics) and outputs (catches) and that it must be possible to link these data. He noted that it is necessary, in addition, to have data relating to variable inputs to account for differences in the skills of the vessel captains. Also, estimates of stock abundance and the effects of environmental conditions, or proxies for these, are required if these are to be incorporated into the analysis.

Dr Reid then presented an overview of the data available for the industrial purse-seine, longline and pole-and-line fleets. A reasonable set of fixed input data (vessel characteristics) could be obtained for the large-scale purse-seine, longline and pole-and-line fleets and, in some cases, for smaller vessels. However, it was noted that, aside from the purse-seine fisheries of the eastern Pacific Ocean (EPO) and the western and central Pacific Ocean (WCPO), it was not possible to obtain and link vessel characteristics and catch and effort data throughout the operational ranges of the vessels. He then noted that the crux of the problem that is faced in trying to conduct DEA at a level of disaggregation for which useful results can be obtained is associating the input data with variable input (effort) and output (catch) data at anything but a fishery level, and that the problem is often not the availability of fixed input data, but the availability of the data in a form appropriate for DEA.

Paper-specific discussion: The issue of the level of aggregation at which DEA could best be conducted was discussed. It was suggested that the DEAs that were conducted for the WCPO and EPO purse-seine fisheries, using the most disaggregated data, be conducted with more highly aggregated data, and the results compared.

The issue of stock abundance at potential estimated catch levels was also discussed. It was noted that the DEA previously undertaken and reported to the second meeting of the Technical Advisory Committee used estimated biomass as an exogenous variable to attempt to account for fluctuations in stock levels among fisheries. It was also noted that the analysis was perhaps best viewed from the perspective of what level of reduction was required to ensure that a given target catch was not exceeded.

The participants agreed that the Workshop Statement should encourage all members of the RFMOs to collect and report data to the RFMOs that would permit vessel characteristics, effort and catch data to be linked at the operational level necessary for analyses of fishing capacity.

It was noted that, while it is likely to be technically feasible to undertake industrial surveys of capacity in tuna fisheries, given that capacity surveys are undertaken in many

countries covering a wide range of industries, there were likely to be issues relating to funding, the multi-jurisdictional nature of the fisheries and possibly other issues that should be considered. A pilot survey might be conducted before undertaking a full-scale survey.

Paper 9: Assessing capacity in the tuna fishery with desirable and undesirable outputs

Dr Squires' presentation pointed out that fisheries management increasingly emphasizes reductions in undesirable outputs, such as bycatches of marine mammals, sea birds, sea turtles, and unmarketable fishes, including juveniles of target species. If managers desire estimates of capacity conditional on recognizing that the bycatches should be reduced, the conventional output-oriented DEA approach yields greater estimates of capacity than do DEA procedures that incorporate reduction in undesirable outputs. An empirical analysis, using data from 251 pelagic longline sets conducted by 12 US vessels in the US Northeast Distant Water area, demonstrated this point. The desirable outputs were swordfish, albacore, yellowfin tuna, bigeye tuna, bluefin tuna, and sharks, and the undesirable output was sea turtles.

Paper-specific discussion: The possibility of using DEA to address issues relating to the simultaneous catch of bigeye (or other fully-exploited species) and skipjack (or other species that are not fully exploited) was discussed, and it was noted that analysis of such issues could possibly be undertaken within the framework presented in the paper.

General discussion

There was some discussion on the relative benefits of moving toward a bio-economic model that is more complex than DEA to incorporate impact by stock level to frontier, but it was noted that that the bio-economic model had its own shortcomings. The participants were reminded that DEA was selected because it is simple, quick and consistent with economic theory and with the way that governments actually consider capacity and capacity utilization. It was pointed that the objective should be to reduce the fishing capacities to levels commensurate with the stock management objectives. It was suggested that analyses be conducted to assess the tradeoffs between data requirements and the reliability of optimal capacity estimates. The Workshop agreed that a common minimum standard of data collection should be established to ensure the availability of data for DEA, with the understandings that this standard should not prevent any organization from collecting more detailed data.

9. REVIEW OF FACTORS AFFECTING FISHING CAPACITY THAT COULD BE REGULATED BY FISHERIES AUTHORITIES
Paper 10: Factors affecting recent development in tuna longline fishing capacity and possible options for management of longline capacity (Part I)

Dr Miyake presented a follow-up of his paper[5] presented at the second Technical Advisory Committee meeting. He summarized the recent developments that might be affecting the fishing capacity of large-scale (overall length greater than 24 m) longliners. The number of large-scale longliners has declined due to effort for capacity management by governments and industry organizations and economic reasons, including competition with smaller longliners and with purse seiners, increasing fuel costs, decreasing prices for tuna, and scarcity of fish. Also, recent changes in market structure, such as establishment, at the ports where sashimi- and steak-grade tuna are landed, of tuna block processing factories and cheaper air-transportation to locations

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[5] Miyake, P.M. 2005. A review of the fishing capacity of the longline fleets of the world. *FAO Fisheries Proceedings* No. 2: 157-170. Rome.

where the fish are consumed, have reduced the prices of longline-caught tunas. On the other hand, bycatch issues might be negatively affecting longline fishing capacity. (This paper is discussed further under Agenda Item 10.)

Paper 11: Tuna fishing capacity: perspective of purse-seine fishing industry on factors affecting it and its management (Part I)

Dr Morón discussed some of the factors affecting estimates of purse-seine capacity and some considerations with respect to these elements that a fleet capacity scheme should contain. An initial consideration related to the actual effect that voluntary agreements, such as the FAO International Plan of Action on fleet capacity, indicates that if management is to be effective it must be applied as mandatory agreements negotiated in the regional fishery management organizations (RFMOs). Some examples of the difficulties in estimating catch rates that could lead to problems in estimation of biomass were presented. Also some other factors, such as skill of the vessel captains, which could affect estimates of fishing effort were discussed. Two existing capacity schemes, those of the IATTC and the Palau Arrangement, were discussed with respect to the purse-seine fishery. (This paper is discussed further under Agenda Item 10.)

Paper 12: Productivity growth in natural resource industries and the environment: an application to the Korean tuna purse-seine fleet in the Pacific Ocean

Dr Squires presented a paper in which it was pointed out that measures of multifactor productivity growth in natural resource industries are biased unless the effects of the environment are taken into account. This paper introduced environmental effects into an output-oriented Malmquist index of multifactor productivity growth to evaluate growth in productivity, technology and technical efficiency for Korean purse-seine vessels fishing for tunas in the western and central Pacific Ocean.

10. REVIEW OF EXISTING MEASURES FOR MANAGING TUNA FISHING CAPACITY AND POSSIBLE IDENTIFICATION OF ADDITIONAL OPTIONS FOR SUCH MEASURES IN THE CONTEXT OF THE OUTCOME OF ADDRESSING AGENDA ITEMS 7 TO 9

Paper 13: Relating DEA estimates of capacity to traditional measures of fishing capacity

Dr Squires presented a paper in which it was pointed out that traditional indicators of fishing capacity, such as vessel numbers or measures of vessel size, such as well capacity, length, or gross registered tonnage (GRT) are widely used to monitor fishing capacity and its changes through time. Data envelopment analysis (DEA) measures of fishing capacity estimate potential output or catch, given this capacity base or capital stock, while assuming that variable input use or fishing effort is unconstrained. DEA measures of fishing capacity, while possessing certain theoretical advantages, can be difficult to estimate and interpret because of complexity, missing data, or lack of timeliness. If changes in traditional measures of fishing capacity are similar to changes in DEA-estimated measures of fishing capacity, then the traditional measures can be readily applied with confidence that they are capturing the underlying situation. A preliminary empirical assessment for the US tropical tuna purse-seine fleet in the western and central Pacific Ocean (WCPO) indicates that the traditional measure holds promise to fundamentally track the DEA-estimated measure if assessed for carefully-considered segments of the fleet. Additional research is required, however.

Paper-specific discussion: The idea that changes in capital stock track changes in fishing capacity was tested in this study. The results indicated that there is no clear relationship between vessel size and fishing capacity in a general sense, but at some aggregation

levels the results are more promising. The Workshop noted that the use of GRT alone as a measure of capacity did not necessarily take into account the range of important factors that influence the catch rates and catch potentials of the vessels. In the absence of information on the influence of these other factors, use of nominal capacity measures such as GRT, number of vessels, or other similar metrics, alone, appears to be a rather blunt instrument for managing fishing capacity. While output capacity may be used for measurement, management measures will probably address capital stock.

Paper 10: Factors affecting recent development in tuna longline fishing capacity and possible options for management of longline capacity (Part II)

Dr Miyake discussed the latter half of Paper 10, which stated that the recommendations made at the second Technical Advisory Committee meeting should be implemented for all the fleets, including small longliners and purse seiners. Particular concern was expressed regarding small longliners, which have been increasing in numbers in recent years, but for which information is incomplete. It was agreed that data for these vessels should be collected and incorporated into stock assessments. This might be accomplished by decreasing the lower limit for the vessel registries to less than 24 m. At the same time, the coastal states should be assisted in developing systems for obtaining statistics for small longliners and managing their capacity.

Paper-specific discussion: The Workshop endorsed the suggestion that the statistical documents needed for importation of tuna, be expanded to include all tunas, especially fresh bigeye and yellowfin tuna, caught of longline vessels, and emphasized the need for more data from small (less than 24 m) longliners, which would require technical and other assistance to developing countries that have vessels of this type.

Paper 14: Requirements and alternatives for the limitation of fishing capacity in tuna purse-seine fleets

Dr Joseph indicated that governments and the tuna fishing industry have expressed great concern regarding the excess fishing capacity in the world's tuna fleets. This could lead to overfishing of some tuna stocks, such as yellowfin and bigeye, and to harvests of skipjack in excess of demand, resulting in reduced ex-vessel prices. Analyses have shown that the fishing capacity of the world's purse-seine fleet, measured as the ability of a vessel or fleet to catch fish, is greater than that needed to sustain the current levels of harvest. There have been a number of efforts by regional fisheries management organizations to implement measures to limit the capacity of some of the tuna fleets operating in their respective regions, most of which have been based on regional vessel registers and allocation schemes, with mixed results. Under the general idea of moving away from open access to rights-based management systems, two categories of options for managing fishing capacity, particularly for purse-seine fleets, are reviewed:
- those that do not remove incentives for overcapacity including (1) a regional vessel register modeled after that of the IATTC, coupled with vessel buyback options, and (2) licensing schemes, including fractional licenses and the use of auctions for the sale and transfer of licenses; and
- those that remove the incentives for overcapacity, especially individual transferable quotas (ITQs), as a self-regulating measure that assigns individual quotas.

A moratorium on new entrants was proposed as a short-term solution. This will allow the studies of how best to implement rights-based long-term solutions, such as a global vessel register, with provisions for vessel transferability, ITQs, coupled with other controls, and the development of selective fishing methods.

The meeting of Regional Fishery Management Organizations, which will take place in Kobe, Japan, in January 2007 offers an excellent opportunity to address the problem of overcapacity of tuna fleets.

Paper-specific discussion: The discussion centered on fishing rights, the need to address the aspirations of developing coastal states, and some of the associated allocation problems. It was also mentioned that management of longline and purse-seine vessels may require different schemes, since longline vessels move among ocean areas more often than do purse-seine vessels.

The Workshop reviewed alternatives to capacity management of the purse-seine fleet, and considered future directions, with the general idea of moving from an open-access system to a rights-based one. It proposed, as a short-term measure, a moratorium on new entries to the purse-seine fleet (except as replacements for vessels that had left the fishery). This will allow, in the long term, the development of more specific measures, such as a global vessel register and ITQs. The Workshop recognized that a necessary antecedent for rights-based management would be the distribution of the available harvest among participants, and that it would be necessary to establish criteria for that. Establishing criteria for allocations would facilitate cooperative efforts to manage fishing capacity. The Workshop endorsed these recommendations.

Paper 11: Tuna fishing capacity: perspective of the purse-seine fishing industry on factors affecting it and its management (Part II)

Dr Morón presented some general considerations concerning the basic elements that a fleet management scheme should contain. The paper offered views on fleet capacity from the industry perspective. It pointed out the need for stakeholder participation at all stages of the process, the need for limitations for both the purse-seine and the longline fleets, the use of simpler management schemes based on the numbers of vessels (or their total carrying capacity), provisions for vessel transfers to add legal security to the system and linking marketing to management.

Paper-specific discussion: The Workshop agreed that simple measures of capacity would be most useful for management purposes, but acknowledged that such measures alone were not likely to achieve the objectives of the Regional Fishery Management Organizations.

Paper 15: Buybacks in fisheries

Dr Squires' presentation described how buybacks of fishing vessels, licenses or access and other use rights and gear can be key management tools to address overcapacity, overexploitation of fish stocks and distribuional issues. Buybacks can also contribute to a transition from an open-access fishery to a more rational one. As a strategic policy tool, buybacks can help restructure relationhips among participants in a fishery, creating positive incentives that reinforce conservation and management objectives. Buybacks, by reducing vessel numbers, increasing profitability, strengthening positive incentives, improving attitudes and lowering exploitation pressures on fish stocks, can also help in the establishment of self-enforcing voluntary agreements among industry participants. Selectively-targeted buybacks can also help conserve ecological public goods, such as species other than tunas, when sets are made on tunas associated with dolphins or floating objects. This paper offered a view of buyback systems as a transition tool toward rights-based management schemes. The review pointed out that some kind of limited-entry system, such as a regional vessel register, must be in place if buybacks are to work efficiently, and discussed some of the details that must be solved in an international setting, such as what to buy back (vessels, rights, or licenses), what to do with vessels removed from the fishery (scrapping, converting to other uses, or transferring to other regions) and discussed some of the supplementary control measures needed.

Paper-specific discussion: The Workshop agreed that buyback programs could provide a basis for transition toward effective rights-based management systems.

TABLE 1
Actions recommended for attaining the long-term objective of instituting rights-based management systems to eliminate overcapacity in tuna fisheries

What to do	Stages in achieving objective		
	Assess current situation	Stabilize in short and medium term	Optimize in long term
Monitor stock status	X	X	X
Monitor fishing capacity	X	X	X
Expand coverage and harmonize regional vessel registers	X	X	X
Expand market monitoring methods	X	X	X
Limit entry by			
Establishing moratoria on capacity		X	
Instituting licensing			X
Establishing a global vessel register			X
Establishing individual transferable quotas and ITEs			X
Voluntary agreements		X	X
Establish allocation criteria		X	X
Monitoring, control and surveillance	X	X	X
Eliminating illegal, unreported and unregulated fishing and encouraging membership in RFMOs		X	X
Buyback programs		X	

General discussion

As a result of the discussions of this section, the Workshop concluded that to have an effective fleet management scheme the first priority should be an immediate stabilization of the world tuna fleet, The scheme would take into consideration the legal security that private operators should have to operate from the different countries participating in the RFMO, facilitating movement of capacity among countries. Compliance would be ensured through application of measures with significant costs to non-compliant parties.

The available evidence indicates that, globally, there is more capacity than needed to harvest most of the stocks of tunas at their maximum sustainable levels. It is the view of the Workshop that institution of effective rights-based management systems would lead to elimination of overcapacity in the tuna-fleets. Full implementation would be a long-term process, involving many complexities in establishing the use rights for the participants in the fisheries. Until such systems have evolved, it is the recommendation of the Workshop that steps be taken to prevent further growth and to reduce global tuna fishing capacity. The steps and subsequent actions that could be taken to realize this objective are summarized in Table 1.

The Workshop recognized that management schemes should make provision for replacement of existing capacity, while ensuring that total fleet capacity does not increase as a result of replacement.

It is important to involve stakeholders, to ensure transparency and to ensure accuracy of the information from which conclusions are drawn. Global coordination is needed to prevent spillover of overcapacity from one region to another.

Complimentary management measures to be used in conjunction with capacity measures could include effort limits, catch limits, time and area closures, conservation incentives and measures to encourage compliance, including, if necessary, trade measures.

11. STATEMENT FROM THE WORKSHOP: DISCUSSION OF CONTENT

The Workshop discussed the content of the Statement, and agreed that it should have a preamble linking it to the previous work of the Technical Advisory Committee. The Workshop further agreed that there should be a section on overcapacity diagnostics, and a list of specific management recommendations.

12. FUTURE RESEARCH RELATED TO THE MANAGEMENT OF TUNA FISHING CAPACITY: FORMULATION OF A PROPOSAL (COMBINED WITH AGENDA ITEM 13)

13. OVERALL DISCUSSION AND RECOMMENDATIONS (COMBINED WITH AGENDA ITEM 12)

FAO indicated that the tasks of the Project's work plan that were of the highest priority were mostly completed, but that there was insufficient funding to undertake other tasks that were held in abeyance until funds became available. The discussion was focused on general needs for additional data and on other technical aspects of the problem of measuring fishing capacity.

In order to improve output-based measures of fishing capacity, more detailed data relating catches to physical measurements, such as numbers of vessels or vessel carrying capacities, is required. Those data that are routinely collected from logbooks and through observer and enforcement programs are, at a minimum, available at national levels and, in some cases, for RFMOs, and these could be made available for research purposes with appropriate arrangements with the owners of the data. At the same time, mandatory data requirements for capacity management should be established in a harmonized way to allow consistent capacity estimates and controls across regions.

In general, data collection and reporting is not a serious problem for industrialized fleet, but the Workshop noted a lack of data for many coastal fisheries with many small vessels that may have large combined capacities. The Workshop agreed that assistance should be provided to those countries in developing and improving their structure and infra-structure required for data collection and controls of capacity management.

Data envelopment analysis (DEA) has been used for estimation of fishing capacity. Many variations of DEA could be used, depending of the quality of the data available and the type of information that is being sought. If the results of the analyses are to be aggregated, the methods and assumptions should be comparable.

The Workshop drew the conclusions and made the recommendations reported under Agenda Item 10 and in the Statement of Agenda Item 11. Furthemore, the Workshop agreed on the following recommendations.

The Workshop noted that all tuna RFMOs have or are developing vessel registers in which vessels are not necessarily identified uniquely and may be reported under different names, and **recommends** that the RFMOs adopt a common database and minimum standards for vessel data and that they combine their individual registers into a common global vessel register.

The Workshop noted that data that can be used for estimating fishing capacity exist for purse-seine and most longline vessels greater than 24 m in length, but was concerned about the paucity of data for other vessels, particularly longline vessels less than 24 m in length, and **recommends** that the states collect input (vessel numbers, characteristics and fishing effort) and output (catch) data that are linked for all parts of the fleet, including an expansion of the statistical document systems to include fresh fish.

During its discussion the Workshop identified the following topics for future research:

- Investigation of changes in fishing power and productivity of fishing vessels over time.
- Studies of methods of fishing directed at one species, particularly skipjack, that minimize the catches of species that are considered to be overfished.
- Further development of methods to estimate fishing capacity based on stock assessment.
- Investigation of the effects of aggregation of data on fishing capacity estimates and the implications for minimum data standards.

- Investigation of the relationships between fishing capacity and the physical characteristics of the vessels.
- Monitoring of socio-economic factors that are directly associated with fishing capacity, including fuel costs, fish prices and diet preferences.

14. STATEMENT FROM THE WORKSHOP: REVIEW OF ITS FIRST DRAFT

The first draft of the Statement was reviewed, and some suggestions were made for changes.

15. OTHER MATTERS

No other matters were discussed.

16. ADOPTION OF THE STATEMENT FROM AND REPORT OF THE WORKSHOP PROVISIONAL LIST OF PAPERS

The Statement in Appendix VI was adopted by the Workshop.

17. ADJOURNMENT

On behalf of FAO and its Project that organized the Workshop, Dr Majkowski thanked all the participants for their valuable technical input to the Workshop. He expressed particular thanks to:

- Dr Robin Allen, Chairman of the Workshop, for very effectively leading the discussions;
- the authors of the papers;
- the rapporteurs;
- Ms Alejandra Ferreira and Ms Mónica Galván for their help during the Workshop.

Dr Majkowski mentioned that FAO and its Project are grateful to all the organizations that provided strong support and substantial contributions to the Workshop. In this respect, he mentioned specifically (1) the IATTC, the host of the Workshop, and (2) the government of Japan, the principal donor to the Workshop.

Programme

Background information

Tuna stocks have traditionally been managed on the basis of information from the stock assessments conducted by scientists. As a result of these assessments, desired values of population parameters or their reference points, including fishing mortality, are routinely estimated for each stock.

If the fisheries management is to include fishing capacity, a desired magnitude of or a desired change of fishing capacity must be estimated. This has been done recently for a few tuna fisheries by means of data envelopment analysis (DEA). DEA is used to estimate the output of fishing capacity and capacity utilization. It calculates a frontier or maximum landings curve, as determined by the best-practice vessels, given the state of technology, environment and stocks (fixed inputs), provided that fishing effort (variable input) is fully utilized under normal operating conditions.

DEA has been performed on a few purse-seine fisheries, but not on other important tuna fisheries, such as longline and pole-and-line fisheries operating on the same or other tuna stocks.

DEA, unlike other types of stock assessment, cannot be performed routinely on most stocks because it requires input data that are not presently available for most tuna fisheries. Industry surveys of tuna fishing capacity utilization have not been performed to any significant extent, if at all.

Because the assessment of stock status is routinely carried out for most stocks of the principal market species of tunas, it might be more practical, if feasible, to determine the desired magnitude of or desired change in fishing capacity from information from these assessments, rather than from DEA or industry surveys of tuna fishing capacity utilization. Fishing effort is considered to be proportional to fishing mortality, but the relationship between fishing effort and fishing capacity is more complicated. Because of that, quantitative methods must be developed to estimate the desired magnitude of or the desired change to fishing capacity on the basis of the status of tuna stocks, taking into account the multi-species and multi-gear nature of the tuna fisheries, which significantly complicates analyses and provision of advice for the management of tuna fishing capacity.

Therefore, the second Workshop of the Technical Advisory Committee of the FAO Project on the "Management of Tuna Fishing Capacity: Conservation and Socio-economics", held in Madrid, Spain, on 15-18 March 2004, recommended that the Project, in collaboration with tuna agencies and programs, should organize a Workshop to develop quantitative methods to determine the desired magnitude of or desired change to fishing capacity on the basis of the status of stocks.

Subsequently, as a result of informal discussions among some members of Technical Advisory Committee, it was proposed that the scope of the Workshop be extended as outlined in the Objectives section below.

Subsequently, a preliminary proposal of the Workshop was prepared by the FAO Project and presented and discussed at the fifth Meeting of the Secretariats of Tuna Agencies and Programs in Rome, Italy, on 11 March 2005. The Workshop generally agreed that it would be a good idea to extend studies on fishing capacity to combine economic and biological considerations. They considered that the outcome of the Workshop would be relevant for the work of their organizations and their member

countries, rendering technical assistance to their fisheries managers in undertaking decisions on the management of tuna fishing capacity.

Objectives
A. To develop quantitative methods to determine the desired magnitude of or desired change to fishing capacity on the basis of the status of the stocks, taking into account the multispecies and multigear nature of the tuna fisheries;
B. To determine the feasibility of (1) routinely collecting input data for data envelopment analysis (DEA) and (2) performing industry surveys of tuna fishing capacity utilization;
C. To relate DEA estimates of fishing capacity utilization to traditional estimates of fishing capacity;
D. To review the factors affecting fishing capacity (numbers of vessels, their physical characteristics, *etc.*) that could be regulated by fisheries authorities;
E. To review the existing measures for managing tuna fishing capacity, and possibly, to identify additional options for such measures in the context of the outcome of addressing Objectives A through D;
F. To prepare a Statement of the participants in the Workshop;
G. To formulate recommendations of the Workshop to the FAO Project on the Management of Tuna Fishing Capacity, FAO and the other organizations participating in the Workshop.

Arrangements for and support to the Workshop
FAO's Project on the Management of Tuna Fishing Capacity is organizing the Workshop, coordinating and contributing to the technical work preparatory to the Workshop. FAO's Regular Programme will also contribute to that work, and some of its experts will participate in the Workshop.

The Inter-American Tropical Tuna Commission (IATTC) in La Jolla, California, USA, will host the Workshop.

Support to the Workshop is being provided by (1) most tuna agencies and programs and (2) some other international and national fisheries organizations, including (3) those of the tuna fishing industry and (4) universities. They include:

- the Forum Fisheries Agency (FFA), the Inter-American Tropical Tuna Commission (IATTC), the International Commission for the Conservation of Atlantic Tunas (ICCAT), the Indian Ocean Tuna Commission (IOTC), the Secretariat of the Pacific Community (SPC);
- the Japan Tuna Fisheries Cooperative Association, the National Marine Fisheries Service (NMFS), the National Research Institute of Far Seas Fisheries (NRIFSF), the World Tuna Purse-Seine Organization (WTPO);
- the College of William and Mary (CWM) and the University of California at San Diego (UCSD).

These organizations are contributing to the technical work preparatory to the Workshop, including the implementation of various studies to be documented in the papers for their presentation at the Workshop. They will also finance the participation of their experts in the Workshop. All the contributions to the Workshop will be fully acknowledged in the Proceedings of the Workshop.

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Provisional agenda

Registration: 8:30 to 9:30 on Monday, 8 May 2006
Sessions: 9:00 (with the exception of the first day—see below) to 17:00
Coffee breaks: 10:30 to 10:45 and 15:15 to 15:30
Lunch breaks: 12:15 to 13:45
Presentation of papers: 20 min. each, followed by 10-min. question-and answer-session with a 90-min. overall discussion at the end of each substantive Agenda Item

Monday, 8 May 2006

1. [9:30] Opening
2. [9:45] Introduction of participants
3. [9:50] Adoption of provisional agenda and of provisional list of papers
4. [9:55] Logistic arrangements for the Workshop
5. [10:05] Statement from and Report of the Workshop: content and logistic arrangements for their preparation
6. [11:00] Overview of the Project and its implementation
7. [11:15] Development of quantitative methods to determine the desired magnitude of or desired change to fishing capacity on the basis of the status of stocks, taking into account the multi-species and multi-gear nature of tuna fisheries

Tuesday, 9 May 2006

8. [9:00] Feasibility of (1) routinely collecting input data for the data envelopment analysis (DEA) and (2) performing industry surveys of tuna fishing capacity utilization
9. [13:45] Review of factors affecting fishing capacity (number of vessels, their physical characteristics, etc.) that could be regulated by fisheries authorities

Wednesday, 10 May 2006

10. [9:00] Review of existing measures for managing tuna fishing capacity and possibly, identification of additional options for such measures in the context of the outcome of addressing Agenda Items 7 to 9
11. [11:15] Statement from the Workshop: discussion of content
    Note: After the completion of Agenda Item 11, the first draft of the Statement will be prepared, probably by a small group of participants, which will be identified at the Workshop for its presentation on the next day (see Agenda Item 14).

Thursday, 11 May 2006

12. [9:00] Future research related to the management of tuna fishing capacity: formulation of proposals
13. [11:15] Overall discussion and recommendations
14. [15:30] Statement from the Workshop: review of its first draft
    Note: After the completion of Agenda Item 14, the first draft of the Statement will be revised for its adoption on the next day (see Agenda Item 16).
15. [16:45] Other matters

Friday, 12 May 2006

16. [9:00] Adoption of the Statement from and Report of the Workshop Provisional List of Papers

17. [11:00] Adjournment

APPENDIX IV

List of papers

P1 Overview of the FAO Project on the Management of Tuna Fishing Capacity and its implementation, by Jacek Majkowski (FAO)

P2 Estimated target fleet capacity for the tuna fleet in the eastern Pacific Ocean, based on stock assessments of target species, by Pablo Arenas (IATTC)

P3 Estimates of large-scale purse-seine, baitboat and longline fishing capacity in the Atlantic: an analysis based on a stock assessment of bigeye tuna, by Victor Restrepo (ICCAT)

P4 A case study of the impact of recent management measures on the overall fishing capacity and fishing effort of the United States longline fleet that fishes in the North Atlantic Ocean, by Gerald P. Scott (NMFS) and Guillermo Díaz (NMFS)

P5 Estimates of large-scale purse-seine and longline fishing capacity in the western and central Pacific Ocean based on stock assessments of target species, by John Hampton (SPC)

P6 Review of existing information and its potential use for analyses and management of fishing capacity, by Sachiko Tsuji (FAO)

P7 Measurement of the global fishing capacity of large-scale tuna purse seiners, by Jacek Majkowski (FAO)

P8 Measuring fishing capacity in tuna fisheries: data envelopment analysis, industry surveys and data collection by Chris Reid (FFA) and Dale Squires (NMFS)

P9 Assessing capacity of the United States Northwest Atlantic pelagic longline fishery for highly migratory species with undesirable outputs, by Tara Scott (CWM), James Kirkley (CWM), Ronald Rinaldo (NMFS) and Dale Squires (NMFS)

P10 Factors affecting recent development in tuna longline fishing capacity and possible options for management of longline capacity by Makoto Peter Miyake (Tuna Japan)

P11 Tuna fishing capacity: perspective of the purse-seine fishing industry on factors affecting it and its management, by Julio Morón (OPAGAC)

P12 Productivity growth in natural resource industries and the environment: an application to the Korean tuna purse-seine fleet in the Pacific Ocean, by Dale Squires (NMFS), Christopher Reid (FFA) and Yongil Jeon (Central Michigan University)

P13 Relating DEA estimates of capacity utilization to traditional measures of fishing capacity by Dale Squires (NMFS), James Kirkley (CWM), James Joseph, Theodore Groves (UCSD) and Chris Reid (FFA)

P14 Requirements and alternatives for the limitation of fishing capacity in tuna purse-seine fleets, by James Joseph, Dale Squires(NMFS), William Bayliff (IATTC) and Theodore Groves (UCSD)

P15 Buybacks in fisheries, by Dale Squires (NMFS), James Joseph and Theodore Groves (UCSD)

Information documents

I1 Report of the Second Meeting of the Technical Advisory Committee (TAC) GCP/INT/851/JPN, Madrid, Spain, 15-18 March 2004

I2   Bayliff, W.H.; Leiva Moreno, J.I. de; Majkowski, J. (eds.) Second Meeting of the Technical Advisory Committee of the FAO Project "Management of Tuna Fishing Capacity: Conservation and Socio-economics". Madrid, Spain, 15-18 March 2004. FAO Fisheries Proceedings No. 2. Rome, FAO. 2005. 336p.

I3   Carocci, F. and Majkowski, J. Tuna catch statistics—FAO collections: status and issues

APPENDIX V

Glossary of terms

Capacity

Capacity refers to the potential to catch fish. Capacity and capacity utilization are short-run concepts, for which at least one input is fixed, especially the capital stock, given the state of technology, the resource stocks and environmental conditions. Capacity has often been indexed by a measure of the capacity base or capital stock, such as an indicator of vessel size (e.g. carrying capacity, length or gross registered tonnage). Capacity has also been indicated by central governments and in the economic literature by a measure of potential output, i.e. by capacity output.

Capacity output (Output capacity)

Capacity output is a potential output, and one of the widely used indicators of capacity. Capacity output can be purged of technical inefficiency (a measure of fishing skill), since technical inefficiency (i.e. fishing skill) is unlikely to vary over the short run. The remaining reason for not producing at full capacity, i.e. capacity utilization not equal to1, comes from not using all of the available fishing effort (variable inputs), given the fixed inputs, state of technology, environmental conditions and the resource stock.

Capacity utilization

Capacity utilization is the ratio of actual output (catch, landings) to some measure of potential output (capacity output) for a given fleet and biomass level. It is a short-run concept.

Capital

Capital is any previously produced input or asset of a vessel or any other producer. As such, capital is a stock. In practice, capital can be thought of as "real" assets, such as vessels, gear and equipment.

Capital utilization

Capital utilization is defined as the ratio of the desired stock of capital to the actual stock of capital and measures the utilization of a given capital stock. Capital utilization differs from capacity utilization. Capacity utilization refers to the utilization of all inputs, rather than not just the stock of capital.

Carrying capacity

Carrying capacity is measured for most tuna fishing vessels as the tonnage of fish that can be stored on the vessel when it is fully loaded or the storage area, measured in cubic metres. Carrying capacity is sometimes used as an indicator of the fishing capacity of a vessel or fleet, and is assumed to be related to the ability of a vessel to catch fish under normal operating conditions.

Data envelopment analysis (DEA)

DEA is a "frontier"-based method: the outputs of individual vessels in the fleet are compared, with the "best" set of vessels, used as a benchmark. The "best" vessels are those that have the greatest levels of output per unit of input. These vessels determine

the "frontier". DEA is a non-parametric technique, solved using a linear programming model, so it cannot deal directly with random error (e.g. "luck" in terms of catch).

Excess capacity
Excess capacity is the difference between fishing capacity and actual harvest.

Fishing capacity
Fishing capacity is the amount of fish (or fishing effort) that can be produced over a period of time (e.g. a year or a fishing season) by a vessel or a fleet if fully utilized and for a given resource condition. Full utilization, in this context, means normal, but unrestricted, use, rather than some physical or engineering maximum.

Fishing power
Fishing power refers to relative efficiency among gear and vessel types, based on total annual or seasonal catches. Following Gulland (1986)[1], fishing power can be defined as the product of the area of influence of the gear during a unit of operation and the efficiency of the gear during that operation. Because the concept of absolute fishing power is difficult to measure, the concept of relative fishing power is frequently used. Relative fishing power is defined by Beverton and Holt (1957, pp. 172-173)[2] as, "The ratio of the catch per unit fishing time of a vessel to that of another taken as standard and fishing on the same density of fish on the same type of ground." More operationally, fishing power of any vessel can be defined by reference to a standard vessel, whose fishing power is expected to be constant, by comparing the catches of these vessels when fishing at the same time and place.

Fixed input (Fixed factor)
Fixed inputs are inputs whose levels are held fixed in a time period; their services do not vary with the amount of the output produced. Examples include the vessel, engine and some gear and equipment.

Inputs (Factors of production)
Inputs are any good or service that contribute to the production of an output. Inputs typically include capital, labour, energy and materials.

Investment
Investment refers to changes in the capital stock in a given time period. **Gross investment** is the sum of replacement investment and net investment in a time period. **Replacement investment** is the amount of investment in a time period designed merely to replace the amount of capital that has deteriorated or has been converted to other uses or scrapped. **Net investment** refers to the net increment to the capital stock since the last time period, and equals total investment minus replacement investment.

Long run
Long run refers to the time period in which all inputs can be adjusted. For example, the capital input (the vessel) is generally fixed in the short term, while fishing effort can be varied. In the long term, fishers can change their vessels or alter their fishing activities. In the short run, capital and equipment are generally viewed as fixed inputs; that is, they cannot be increased or decreased. For example, a vessel size cannot be changed in

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[1]   Gulland, J.A. 1983. *Fish Stock Assessment: a Manual of Basic Methods*. New York, FAO/Wiley Series on Food and Agriculture, Vol. 1: 223 pp.

[2]   Beverton, R.J.H., & Holt, S. J. 1957. On the dynamics of exploited fish populations. *Minis. Agri. Fish. Food, Fish. Inves.*, Ser. 2, 19: 533 pp.

the short-run. Over the long run, however, capital and equipment may be viewed as variable inputs. They can be changed. A vessel owner, for example, can modify a vessel or replace it with a larger or smaller one.

Overcapacity
Overcapacity can be considered the generic term for excessive levels of capacity in the longer term, and it relates to some long-term desirable level of capacity (the target capacity). This may be either some long-term target sustainable yield, or some long-term target level of capital employed in the fishery.

Overcapitalization
Overcapitalization refers to an actual capital stock that is in excess of that optimum capital stock required to produce some optimum output level. Overcapitalization occurs through over-investment in capital.

Overcapacity and overcapitalization
Overcapitalization refers to only the capital stock, whereas overcapacity is more all-encompasing in that it includes all fixed inputs (capital such as the vessel and engine) and variable inputs to harvest operations, such as labour (crew), fuel, ice and other relevant variables.

Production frontier
The production frontier represents the maximum output attainable from each input level, given the current state of technology in the fishery, environmental conditions and resource stocks. The term **best-practice production frontier** refers to the production frontier established by the vessels with the highest production performances, as opposed to an engineering concept in which the production frontier is established solely on engineering or technical grounds.

Peak-to-peak method
The peak-to-peak method measures capacity by measuring the observed relationship between catch and fleet size. Periods of greatest catch, given the harvesting technology, capital stock, resource stock and state of technology, provide measures of full capacity. The approach is called the peak-to-peak method because the periods of full utilization, called peaks, are used as the primary reference points for the capacity index. Changes in peak catch rates are assumed to be due tochanges in technology or resource stock conditions.

Short run
Short run refers to the time period in which at least one input is held fixed, *i.e.* there is a fixed input. For example, in the case of fisheries, the capital input (the vessel) is generally fixed in the short term, while fishing effort can be varied. In the long term, fishers can change their vessels or alter their fishing activities.

State of technology
State of technology refers to the current, existing state of technical knowledge as to how goods and services can be produced. **Changes in the state of technology** refer to **technical change** or **technical progress**.

Target capacity
Target fishing capacity is the maximum amount of fish over a period of time (year, season) that can be fully utilized while satisfying fishery management objectives designed to ensure sustainable fisheries, *i.e.* $Y_T = Y(E_T, S)$, where Y_T is the target yield

or catch, E_T is the target effort generated by a fully-utilized fleet, and S is the stock size (biomass).

Technical efficiency

Technical efficiency (TE) occurs when the maximum amount of an output is produced for a given set of inputs (output-oriented technical efficiency) or when the minimum amount of inputs are required to produce a given output level (input-oriented technical efficiency). TE ranges between 0 and 1. TE is 1 when a vessel is full technically efficiency, so that it cannot catch any more fish with the available inputs (fishing effort and vessel). TE <1 when a vessel is not fully technically efficient, *i.e.* when it is technically inefficient. A vessel is inefficient because technically it could increase its catch to the level of the best-practice production frontier without requiring more input.

Total factor productivity (Multi-factor productivity)

Productivity of a vessel is the ratio of the output(s) (Y) it produces to the input(s) (X) it uses, *i.e.* productivity = outputs/inputs or Y/X. **Total factor productivity** refers to a productivity measure involving all inputs. In the presence of multiple outputs and multiple inputs, total factor productivity may be defined as a ratio of aggregate output produced relative to aggregate input used. **Partial productivity** refers to a productivity measure that does not involve all inputs, and usually refers to a productivity measure involving only one input. Examples of partial productivity measures are output per worker, output per hectare or catch per unit of effort. **Productivity growth** refers to an increase in productivity over time, *i.e.* where the ratio of output to input increases over time or $\dot{Y}/Y - \dot{X}/X$.

Variable inputs (Variable factors)

Variable inputs are inputs that can be freely varied in a time period, and hence vary according to the amount of output produced. Examples of variable inputs in fisheries include fuel, bait, light sticks, sometimes crew and some gear and equipment.

APPENDIX VI

Statement from the Workshop

Statement from the Workshop on the Management of Tuna Fishing Capacity
La Jolla, California, USA, 8-12 May 2006

This Workshop is the third meeting convened by the FAO Project created in response to concerns about overcapacity in tuna fisheries on a global scale. The third meeting recalled and built on the conclusions and recommendations from the two previous meetings.

The available evidence indicates that globally there is more capacity than needed to achieve the management objectives for most tuna stocks. Notwithstanding management measures implemented by Regional Fishery Management Organizations (RFMOs), overcapacity has already led to overexploitation of some tuna stocks, and it is likely to lead to overexploitation of other tuna stocks that are close to being fully exploited. This puts tuna stocks and the fisheries for them at a significant risk.

It is the view of the Workshop that effective rights-based management systems will lead to elimination of overcapacity in the tuna fleets. The Workshop recommends that steps, as listed below, be taken to prevent further growth of fishing capacity.

Rights-based management systems allow individual vessel owners to transfer the capacity of their vessels to other countries participating in the RFMO and make provision for the replacement of existing capacity, while ensuring that the total fleet capacity does not increase as a result of replacement. Compliance should be ensured through application of measures with significant cost to non-compliant parties. The Workshop recognizes the importance of involving stakeholders to ensure transparency and to ensure accuracy of the information from which conclusions are drawn. Global coordination is needed to prevent spillover of overcapacity from one region to another.

The Workshop recommends that the management of fishing capacity should include:
1. an immediate moratorium on the entry of additional large-scale vessels;
2. allocation criteria and mechanisms to provide for new participants;
3. participation by all tuna fishing nations and fishing entities in tuna RFMOs;
4. improved monitoring of tuna fishing fleets and their activities, to facilitate control of fishing capacity regionally and globally;
5. collection, by states, fishing entities and RFMOs, of information on activity of vessels that are not currently monitored;
6. limited entry to regional registers of vessels that fish for tunas that, in combination, provide a global register;
7. use of buybacks or similar incentives to reduce overcapacity;
8. assurance of the rights of participants in the fishery and incentives for their contributions to conservation and management; and
9. a high level of transparency by including participation of stakeholders in the management at every step.

The Workshop recommends that this Statement be presented to the meeting of tuna RFMOs and their Members to be held in Kobe, Japan, in January 2007, and offers this Statement to the RFMOs and their Members for their consideration.