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FAO/GOVERNMENT OF JAPAN
COOPERATIVE PROGRAMME WORKSHOP REPORT

MANAGEMENT OF TUNA FISHING CAPACITY: CONSERVATION AND SOCIO-ECONOMICS GCP/INT/851/JPN

REPORT OF THE

Methodological Workshop on the Management of Tuna Fishing Capacity: Stock Status, Data Envelopment Analysis, Industry Surveys and Management Options

La Jolla, CA, USA, 8-12 May 2006

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Methodological Workshop on the Management of Tuna Fishing Capacity: Stock Status, Data Envelopment Analysis, Industry Surveys and Management Options

FAO Project
on the Management of Tuna Fishing Capacity:
Conservation and Socio‑economics

in collaboration with and with support from

the Forum Fisheries Agency (FFA), 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 Federation of Tuna Fisherman's Association (Japan Tuna), the National 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, San Diego (UCSD).

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1 OPENING

Robin Allen, the Director of the institution hosting the Workshop and its Chairman welcomed its participants at the Inter-American Tropical Commission (IATTC) in La Jolla, CA, USA.

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

- for finding funds for coming to La Jolla and
- the substantial technical work preparatory to the Workshop, which was done in a very timely way.

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

- IATTC as the host of the Workshop and its Director and other staff for all the excellent 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 the Program of the Workshop in Appendix I), Majkowski indicated that he is looking forward to the active participation of all experts in the Workshop, which will allow to fulfill these objectives.

2 INTRODUCTION OF PARTICIPANTS

The Chairman, Robin Allen asked participants of the Workshop to introduce themselves, indicating their institutional affiliation (see their list in Appendix II).

3 ADOPTION OF THE PROVISIONAL AGENDA

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

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

4 LOGISTIC ARRANGEMENTS FOR THE WORKSHOP

The Director of the host institution (IATTC) and Convener of the Workshop presented logistic arrangements for `the meeting. The Convener of the Workshop suggested the following rapporteuses

- Jacek Majkowski – Agenda 1 to 6
- John Hampton and Victor Restrepo - Agenda 7
- Sachiko Tsuji and Chris Reid - Agenda 8
- Peter Miyake and Julio Morón - Agenda 9
- Pablo Arenas and Gerald P. Scott - Agenda 10 and 11

- William Bayliff and Sachiko Tsuji - Agenda 12
- James Joseph and Nazoumi Miyabe - Agenda 13
- Jacek Majkowski - Agenda 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

The Convener of the Workshop proposed that the participants will suggest the content of the Statement during the session associated with Agenda Item 11. The Workshop 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*

Jacek 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 form of studies and meetings. Then, he concentrated on the outcome of the previous meeting organized by the Project (2nd Meeting of Technical Advisory Committee (2nd TAC) 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 very end of his presentation, he recalled the objectives of the Workshop (see the Program of the Workshop in 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 size for the tuna fleet in the eastern Pacific Ocean, based on stock assessments of target species*

Pablo Arenas presented how IATTC has considered the issue of carrying capacity of the tuna fleet in the EPO since 1998. A target of 158,000 m3 for the purse-seine fleet has been adopted by IATTC. No target for the longline fleet has been established, but catch limitations for this gear were established for 2004 through 2006. Factors affecting the fishery and management tradeoffs are discussed, and the approach to the establishment of a target capacity taken 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 repercussions and assessment and simulation results are reviewed for both gears, with consideration of the multi-gear and multi-species nature of the fishery. It is concluded that the target of 158,000 m^3 for the purse-seine fleet is still appropriated (unless species-specific fishing methods, especially for skipjack, can be developed), but the fleet size is now 20%-25% above it. A target effort of 160 million hooks for the longline fleet was suggested (at about the levels of 2001-2002). It was concluded that with the current mix of gears, the size of both fleets is above what would facilitate conservation of the tuna stocks in the EPO.

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

Victor Restrepo described an approach for estimating 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, and it also provided estimates of excess capacity based on maximum sustainable yield. 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 capacity in fisheries science, as well as with the technological-economic approach.

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

Gerry Scott provided a brief case study of recent management actions taken regarding the USA Atlantic pelagic longline fleet and their combined effects on several indicators of fleet effort and capacity for harvesting swordfish. Over the past decade, during the period of active management, there has been decline in various measures of USA Atlantic pelagic longline fishing effort and capacity. Over the past few years, USA vessels have not achieved domestic MSY-based Total Allowable Catch (TAC), although volumes of dead discarded fish (mainly of undersized fish) remained. Based on information available from generalized linear modeling used to standardize catch rate patterns for stock assessment, the range of relative efficiencies of different fishing strategies within the fleet indicates sufficient capacity is held within the remaining fleet to achieve domestic TAC if a greater proportion of the fleet could apply higher efficiency fishing strategies already existing within the fleet. Use of information held within similar standardization analyses could be more broadly applied to estimate capacity frontiers amongst the fleets harvesting tuna and tuna-like species.

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*

John 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 multi-species 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 equally address the stock status of all species simultaneously. Secondly, the problem of “effort creep” is significant for capacity and other effort-based management systems. If such measures are employed, it is essential that limits are regularly reviewed and if necessary adjusted downwards to counter “effort creep”. Thirdly, 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 fishery composition. However, it is shown that altering the mix of gear types, and hence altering the overall size selectivity of the fishery, can have very different outcomes for stock status and productivity. Therefore, appropriate levels of fishing capacity in one component of the fishery will depend on the capacity in 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 stock abundance through 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 fisheries are defined for the purposes of measuring capacity. For example, tuna stock assessments frequently define fisheries according to set type and spatial region. 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 is something that should be incorporated into output-based capacity measures. DEA accommodates this by incorporating such variability into the data, which effects 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 approach for the purpose of capacity estimation might be to re-define the purse-seine fisheries as a single entity, and in a similar way to DEA 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 where some fisheries capture small fish and others capture large fish, 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 (either determined by stock assessment models or methods such as DEA) in fisheries management, the output-based measure needs to 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 related to the level 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 (i) ROUTINELY COLLECTING INPUT DATA FOR THE DATA ENVELOPMENT ANALYSIS (DEA) AND (ii) PERFORMING INDUSTRY SURVEYS OF TUNA FISHING CAPACITY UTILIZATION

Paper 6: *Review of existing information and their potential use for analyses and management of fishing capacity*

Sachiko Tsuji presented the quick overlook of data potentially to be used for management of tuna fleet fishing capacity. Tunas were taken by relatively small number of countries of about 60 countries over 95% of global catches as well as those heavily relied on tunas and most of them already participated to Regional Management schemes. Although a variety set of vessel information became recently available to public, those should be linked together as well as with other information on fishing activities and transaction to make them usable in capacity management purpose. Document proposed an inclusion of fishing activity quota in addition to catch quota together with ceiling of tuna vessel capacity, which would facilitate fishing activity management directly linked with assessment results, transfer of catch quota among different gears or fleets, and shift of operational pattern toward desired direction. For successful implementation of fishing capacity management, the strong commitment by tuna fishing countries and the integrated global vessel data sharing system were essential in addition to a good collaboration among tuna management bodies and some mechanism to detect, and discourage if possible, new entries to tuna fishing activities in any form.

Paper-specific discussion. - During the discussion, it was pointed that the catch reported by RFBs included catches taken by non-participating countries, so the coverage by regional management schemes might be even higher than presented. It was noted that the vessel information available in public should not be regarded as estimates of fleet size catching tunas and the importance of reliable fleet statistics was re-emphasized. Corresponding to the question, it was explained that the global high sea vessel monitoring mechanisms was currently a center of interests of many different bodies and that many attempts were underway in parallel to establish such mechanism. The importance of coordinated initiatives between FAO and RFBs was expressed for development of such mechanisms acceptable for both fishing countries and conservation groups.

Paper 7: *Measurement of the Global Fishing Capacity of Large - Scale Tuna Purse Seiners*

Jacek Majkowski mentioned that the 2nd Meeting of TAC recommended to update the estimates of the number of large-scale purse seiners and their carrying capacity that were obtained for 2000 by Jim Joseph (2003)[1] . The update proved to be more difficult than expected because of no system of routinely collecting information for obtaining such estimates. Therefore, the estimates are not necessarily comparable between years. He explained the source of information for the update, i.e.,

- Atlantic: mostly information from governmental institutions of France, Spain and Venezuela and to a lesser extend, the register of tuna vessels created by the International Commission for the Conservation of Atlantic Tuna (ICCAT),

[1] Joseph, J. 2003. Managing fishing capacity of the world tuna fleet. FAO Fisheries Circular. No. 982. Rome, FAO. 67p.

- Indian and eastern Pacific Oceans: registers of tuna vessels created by the Indian Ocean Tuna Commission (IOTC) and the Inter-American Tropical Tuna Commission (IATTC), and
- western and central Pacific: the study carried out by Gillett and Lewis (2003)[2].

Then, he 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 number of purse seiners in the Atlantic for 2004 seemed to be smaller than for 2000. For the Indian and eastern Pacific, the number of purse seiners in 2000 and 2004 were very similar. They were smaller for the western and central Pacific for 2004 than for 2000 possibly because of no inclusion of purse seiners registered in coastal countries of the region and operating only in their EEZ. In addition, the carrying capacity in all oceans appeared smaller for 2004 than in 2000 possibly due to the use of too low ratio for converting to the 2004 hold volume to carrying capacity. Majkowski concluded that the differences between the estimates obtained for 2000 and 2004 may not be indicative of changes to purse-seine capacity, but a reflection of difficulties in making them.

Paper-specific discussion. - It was pointed out that the vessel registration data would be useless unless registration was mandatory and utilized to control fleet capacity, which also emphasized the need to bring all data collected by various organizations into global database. Clarification was sought on several existing conversion factors into cubic meters and it was explained that the figure of 1.17 was originally developed based on American shipyard data about 20 years ago but that more recent information indicated higher conversion such as 1.4 in the eastern Pacific. With respect to the problems in obtaining registration data of small vessels only operating within their own EEZ, it was noted that only few vessels in the western and central Pacific stayed inside of their own EEZ and that those small vessels information was generally obtained from logsheets provided when operating other countries' EEZ. It was affirmed that this problem was more typical for Philippines and Indonesia.

Paper 8: *Measuring fishing capacity in tuna fisheries: Data Envelopment Analysis, industry surveys and data collection*

Chris Reid provided an overview of DEA and data requirements to allow for DEA. It was noted that to allow for a meaningful DEA to be undertaken at a minimum data was required at least some degree of disaggregation from the fishery level on fixed inputs (vessel characteristics) and outputs (catch) and that these data must be able to be linked. It was noted that to account for difference in skipper skill levels it was necessary in addition to have data relating to variable inputs. In addition to account for changes in stock and environmental conditions estimates of these or proxies for them were required.

An overview of data availability for the industrial purse-seine, longline and pole and line fleets was then presented. It was noted that a reasonable set of data of fixed inputs (vessel characteristics) could be obtained for larger scale purse-seine, longline and pole and line fleets and in some case smaller scale vessels. However, it was noted that aside from the purse-seine fisheries of the WCPO and EPO that it was not possible to obtain and link vessel characteristics and catch and effort data throughout the operational range of the vessels. It was further noted, however, this is not the crux of the problem that is faced in trying to do DEA at a level of disaggregation from which worthwhile results can be obtained. The problem is associating the input data with variable input (effort) and output (catch) data at anything but a fishery level and

[2] Gillet, R & Lewis, A. 2003. A survey of purse–seine fishing capacity in the western and central Pacific Ocean, 1988 to 2003. Gillet, Preston and Associates

that the problem is often not one of the availability of fixed input data but the availability of the data in an appropriate form for DEA.

Paper-specific discussion. - The issue of the level of aggregation at which DEA could best be conducted was raised and discussed. It was suggested that for the WCPO and EPO purse-seine fishery for which DEA was conducted using the most disaggregated data of any of the analysis undertaken that an comparative analysis using more highly aggregated data should be undertaken.

The issue of stock availability at potential estimate catch levels was also discussed. It was noted that the DEA analysis previously undertaken and report to the 2nd meeting of the TAC used estimated biomass as an exogenous variables to try and account for fluctuations in stock levels between 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.

Participants agreed in the Workshop statement to encourage all Members to collect and report data to RFMOs allowing for vessel characteristic, effort and catch data to be linked at the operational level to allow for analysis of fishing capacity to be undertaken.

It was noted that while it is likely to be technically feasible to undertake industrial survey 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 needed to be worked through and a pilot survey was one option to do this.

Paper 9: *Assessing Capacity in the Tuna Fishery With desirable and undesirable outputs*

Dale Squires presented that fisheries management increasingly emphasizes reductions in undesirable outputs or bycatch, e.g., marine mammals, sea birds, juvenile species, non-marketable species, and sea turtles. If managers desire estimates of capacity conditional on recognizing that the production of bycatch should be reduced, the conventional output-oriented DEA approach yields higher estimates of capacity than do DEA procedures designed to incorporate a reduction in undesirable outputs. An empirical analysis demonstrated this point using data from at-sea experiments conducted in the U.S. Northeast Distant Water area by 12 U.S. vessels of 251 pelagic longline sets. The desirable outputs in this study included swordfish, albacore, yellowfin tuna, bigeye tuna, bluefin tuna, and sharks, and the undesirable output was the number of sea turtles caught in experimental sets of pelagic longlines.

Paper-specific discussion. - The possibility of using the analysis to address issues relating to the simultaneous catch of bigeye (or species approaching or over MSY) and skipjack (or species whose catches were below MSY) was discussed with it being noted that analysis of such issue could possibly be undertaken within the framework presented in the paper.

General discussion

There was some discussion on relative benefits to move toward more complex bio-economic model than DEA to incorporate impact by stock level to frontier, though it was noted that bio-economic model also had its own shortfalls. It was reminded that DEA was selected since simple and quick. It was pointed that the objective should be to reduce the capacity to level commensurate with stock management objective. Suggestion was made for analyses on impacts by aggregating data to assess the trade-off between data requirement and reliability of optimal

capacity estimates. The Workshop agreed that the common minimum standard of data collection should be established to assure data availability for DEA with the understandings that this standard should not provide any restriction in the case wishing for further data collection.

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)*

Peter Miyake presented as the follow up of the paper presented at the 2nd TAC meeting. In this paper, the recent developments which might be affecting the fishing capacity of large longliners have been reviewed. Due to the efforts for capacity management by respective Government and industry, economical reasons, and through the competitions with small longliners and seiners, the number of large longline vessels, their catches and the fishing capacity have declined and still declining. In addition to the capacity control, the rising fuel cost, lowering tuna product prices, and heavier competitions with other fishing fleets for limited tuna resources in the world are reducing the large longliners fishing capacity. Also recent changes in market structure, such as establishments of cheaper air-transportation, and establishing tuna block processing factories near the landing ports for sashimi and tuna steak markets, greatly contribute cutting down the production cost of longline catches, particularly of the coastal small vessels. On the other hand, by-catch issues might be affecting negatively the longline fishing capacity. (Further information on this document is included under Agenda Item 10)

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

Julio Morón presented some of the elements affecting estimates of purse-seine capacity and some considerations in respect to the elements that a fleet capacity scheme should contain. An introductory consideration in relation with the actual effect that voluntary agreements like FAO IPOA on fleet capacity, leads to believe that effective management should be applied as mandatory agreements negotiated in RFMOs to be really effective. Some examples of the difficulties of estimating catch rates that could lead to biomass indicators were presented. Also some considerations to other factors affecting effective fishing effort were provided, with an example on how skipper performance could affect fishing effort estimates. Existing capacity schemes, IATTC and the Palau Arrangement, were considered giving the purse-seine industry perspective. (Further information on this document is included 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*

Dale Squires presented that measures of multi-factor productivity growth in natural resource industries are biased without accounting for the effects on the environment. This paper introduces environmental effects into an output-oriented Malmquist index of multi-factor productivity growth to evaluate growth in productivity, technology, and technical efficiency for Korean purse-seine vessels fishing for tuna in the Western and Central Pacific Ocean.

10 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

Paper 13: *Relating DEA Estimates of Capacity to Traditional Measures of Fishing Capacity*

Dale Squires presented that traditional indicators of fishing capacity, such as vessel numbers or other measures of vessel size, such as well capacity, length, or registered tonnage are widely used to monitor fishing capacity and its changes through time. 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 for reasons of complexity, missing data, or timeliness. If traditional measures of capacity track changes in DEA-estimated measures of fishing capacity in a reasonably consistent manner, then traditional measures can be readily applied with confidence that they are capturing the underlying situation. A preliminary empirical assessment for the U.S. tropical tuna purse-seine fleet in the WCPO indicates that the traditional measure holds promise to fundamentally track the DEA-estimated measure if assessed for carefully considered sections of the fleet. Additional research is required.

Paper-specific discussion. - The idea that changes in capital stock track changes in capacity was tested in this study. Results showed that there is no clear relationship between size and capacity on a general sense, but under 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 which influence catch rate and catch potentials of vessels operating in the fleets. 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 fleet capacity and achieving conservation objectives. 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)*
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Peter Miyake expressed as the latter half of Paper 10 that the recommendations made at the second TAC meeting should be implemented for all the fleets, including small longliners and purse seiners. Particular concern is expressed on small longliners whose capacity seems to have been increasing in recent years, while fleet statistics are very incomplete. In order to implement the capacity monitoring and managements for small longliners, suggestions were made to expand statistical document system beyond the present scope and/or lower the limit of positive vessel list below the 24 meters. At the same time, assistance would be essential to the coastal states to develop system of getting statistics from the small longliners and manage their capacity.

Paper-specific discussion. - The workshop endorsed to expand the Statistical Documents needed for import of tuna, to include all the tuna catch of the longline fleet, especially for fresh BET and YFT, and emphasized the need for more data from small (less than 24m) longliners--which will require of technical and other assistance to developing countries which have this type of tuna fleets.

Paper 14: *Requirements and Alternatives for the Limitation of Fishing Capacity in Tuna Purse-Seine Fleets*

James Joseph indicated that governments and the tuna fishing industry have expressed great concern for the excess fishing capacity in the world's tuna fleets. Such a state could lead to overfishing of some tuna populations such as yellowfin and bigeye, and to harvests of skipjack in excess of demand, resulting in reduced ex-vessel prices. Analyses have shown that fishing capacity for the world's purse-seine fleet, measured as the ability of a vessel or fleet to catch fish, is greater than needed to sustain current levels of harvest. There have been a number of efforts by regional tuna fisheries bodies to implement measures to limit the capacity of some tuna fleets operating in their respective regions, mostly based on regional vessel register systems 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 the incentives driving overcapacity including (i) a regional vessel register modelled after the IATTC approach, coupled with vessel buy-back options, and (ii) licensing schemes, including fractional licenses and the use of auctions for the sale and transfer of licenses. (i.e. vessel registers, licensing, fractional licensing, and similar), and
- those that remove the incentives for overcapacity, especially ITQs, as a self-regulating measure which assigns individual quotas.

A moratorium on new entrants is proposed as a short-term solution. This will allow the studies and details needed to consider rights-based long-term solutions, such as a Global Vessel Register with provisions for vessel transferability, and ITQs, coupled with other controls and the development of selective fishing methods.

2007 Kobe Tuna Meeting of RFMOs offers an excellent opportunity to address the problem of over-capacity of tuna fisheries and formulates the means to resolve it.

Paper-specific discussion. - The discussion centered on the fishing rights, the need to address aspiration of developing coastal states, and some of the associated allocation problems. It was also mentioned that capacity of the longline fleet may require of a different management scheme, since many boats often move between oceans.

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 vessels to the purse-seine fleet (with provisions for replacement). 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 necessary antecedent for right-based management was the distribution of available harvest among participants and it would be necessary to establish criteria for that. Establishing criteria for allocations will facilitate cooperative efforts to manage fishing capacity. The Workshop endorsed these recommendations.

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

Julio Moron presented some general considerations of the basic elements that a fleet management scheme should contain. The paper offered views on fleet capacity from the industry perspective.

The paper 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 number of vessels (or capacity in cubic meters), provisions for vessel transfers to add legal security to the system, and linking market to management.

Paper-specific discussion. - The Workshop agreed that simple measures of capacity would be most useful for management purposes, but also acknowledged that such measures alone would not likely achieve RFMOs conservation objectives.

Paper 15: *Buybacks in Fisheries*

Dale Squires presented 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 distributional issues. Buybacks can also contribute to a transition from an open-access fishery to a more rationalized one. As a strategic policy tool, buybacks can help restructure relations 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 the incidental bycatch of species other than tunas when sets are made on dolphins or floating objects. This paper offered a view of buyback systems as a transition tool towards rights-based management schemes. The review pointed out that some limited entry system (such as an RVR) must be in place for buybacks to work efficiently, and discussed some of the details that will need to be solved in an international setting, such as what to buyback (vessels, rights, licenses), what to do with vessels out of the fishery (scrap, transfer), and discussed some of the supplementary control measures needed.

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

General discussion

As a result of the discussions of this section, the group concluded that to have an effective fleet management scheme an immediate stabilization of the world tuna fleet is needed as a first priority. The scheme should take in 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 should be ensured through application of measures with significant cost to non compliant parties.

The available evidence indicates that globally, there is more capacity than needed to achieve the stock management objective for many of the tuna populations. It is the view of the Workshop that institution of effective rights-based management systems will lead to elimination of overcapacity in the tuna-fleets. Full implementation would be a long-term process, involving many complexities in establishing the property rights for the fisheries participants. Until such systems have evolved, it is the recommendation of the Workshop that steps be taken to prevent further growth and further to reduce global tuna fishing capacity. Table 1 summarizes steps and subsequent actions that could be taken to realize this objective. An effective fleet management scheme and immediate stabilization of the World tuna fleet is needed as a first priority. The scheme should take into consideration the right of individual vessel owner to transfer its capacity

between different countries participating in the RFMO. Compliance should be ensured through application of measures with significant cost to non compliant parties.

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

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

Table 1: Summary of actions recommended during Workshop discussion to attain the long-term objective of instituting rights-based management systems to eliminate overcapacity in tuna fisheries

	Stages in achieving objective		
What to Do?	**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/Harmonize Regional Vessel Registries	X	X	X
Expand Market Monitoring Methods	X	X	X
Limit Entry, by: Establishing Moratorium on Capacity		X	
Limit Entry, by: Instituting Licensing Establishing Global Vessel Register ITQ/ITE			 X X X
Voluntary Agreements		X	X
Establish Allocation Criteria		X	X
Monitoring, Control and Surveillance	X	X	X
Eliminate IUU encouraging membership in RFMOs		X	X
Buyback Programs		X	

Complimentary management measures to be used in conjunction with capacity measures could include effort limitation, catch amount regulation, time and area closures, conservation incentives, and measures to encourage compliance including 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 section linking it to previous TAC work. The group further agreed that these 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 PROPOSAL (combined with Agenda Item 13)

13 OVERALL DISCUSSION AND RECOMMENDATIONS (combined with Agenda Item 12)

FAO indicated that priority tasks of the project's work plan were mostly completed but there was insufficient funding to undertake other tasks that were held in abeyance until fund became available. The discussion was focused on general need of additional data and on other technical aspects.

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

In general, data collection and reporting is not a serious problem for industrialized fleets but the meeting noted a lack of data for many coastal fisheries with small vessels that may have a large combined capacity. The meeting 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 to be aggregated, the methods and assumptions should be comparable.

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

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

The Workshop noted that data that can be used for estimating fishing capacity exist for purse-seine and most long line vessels larger than 24 m, but was concerned about the paucity of data for other parts of the fleet, particularly long line vessels smaller than 24m, and **recommends** that

states collect input (vessel numbers, characteristics and efforts) and output (catches) data that are linked together for all parts of the fleet including an expansion of the statistical document systems to include fresh fish or adopt catch certificate system.

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.
- Conducting research on methods of fishing directed at one species, particularly skipjack, that minimize the catches of species that are considered to be over-fished.
- 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 relationship between fishing capacity and the physical vessel characteristics of the fleet.

Monitor socio-economic aspects which are directly associated with fishing capacity, including fuel cost, fish price, and diet preferences.

14 STATEMENT FROM THE WORKSHOP: REVIEW OF ITS 1ST DRAFT

The 1st draft of the Statement was reviewed and some suggestions were made for changes.

15 ADOPTION OF THE STATEMENT FROM AND REPORT OF THE WORKSHOP PROVISIONAL LIST OF PAPERS

The Statement given in Appendix VI was adopted by the Workshop

16 OTHER MATTERS

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

- Robin Allen, Chairman of the Workshop for very efficiently leading the discussion,
- the authors of the papers,
- the rapporteuses, and
- Alejandra Ferreira and Monica B. Galván for all their help during the Workshop.

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

APPENDIX I – WORKSHOP PROGRAM

FAO Project
on the Management of Tuna Fishing Capacity:
Conservation and Socio - economics

in collaboration with and with support from

Tuna Agencies and Programs,
other international and national fisheries institutions
including those of tuna fishing industry
and universities

Methodological Workshop on the Management of Tuna Fishing Capacity:

Stock Status, Data Envelopment Analysis,
Industry Surveys and Management Options

Program

Background Information

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

If the fisheries management is to include that of fishing capacity, a desired magnitude of or desired change to fishing capacity needs to be estimated. This has been done recently for very few tuna fisheries on the basis of Data Envelopment Analysis (DEA). This analysis 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) and provided that fishing effort (variable input) is fully utilized under normal operating conditions.

The tuna fisheries for which DEA has been performed are limited to few purse-seine fisheries, but they do not include other important tuna fisheries (like those using longlines and pole - and - lines) operating even on the same tuna stocks.

Presently, DEA is not performed routinely like stock assessments and requires input data different to those for stock assessments, which are presently not available for most tuna fisheries. Industry surveys of tuna fishing capacity utilization have not been performed either to any significant extent, if at all.

Because the assessment of stock status is routinely carried out for, at least, principal market tuna species, it might be more practical, if feasible, to determine the desired magnitude of or desired change to fishing capacity on the basis of 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 need to be developed and/or established to determine the desired magnitude of or 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 tuna fisheries. This nature of tuna fisheries significantly complicates analyses and provision of advice for the management of tuna fishing capacity.

Therefore, the 2nd Workshop of the Technical Advisory Committee (2nd TAC) of the FAO Project on the "Management of Fishing Capacity: Conservation and Socioeconomics" (held in Madrid (Spain) in March 15 to 18, 2004) recommended that the Project in collaboration with the 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 TAC, it was proposed to extend the scope of the Workshop 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 5th Meeting of the Secretariats of Tuna Agencies and Programs (Rome, Italy, March 11, 2005). The Workshop generally agreed that it could 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 very relevant for the work of their institutions and their member countries, technically assisting 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 stocks, taking into account the multi-species and multi-gear nature of tuna fisheries
B. To determine the feasibility of (i) routinely collecting input data for the Data Envelopment Analysis (DEA) and (ii) 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 (number 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 to D
F. To prepare a Statement of participants of the Workshop
G. To formulate recommendations of the Workshop to the FAO Project on the Management of Tuna Fishing Capacity, FAO and the other institutions 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 its experts will participate in the Workshop.

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

Support to the Workshop is being provided by (i) most Tuna Agencies and Programs, (ii) some other international and national fisheries institutions including those of tuna fishing industry and (iii) universities. They include:

- the Forum Fisheries Agency (FFA), 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 Federation of Tuna Fisherman's Association (Japan Tuna), the National 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, San Diego (UCSD).`

These institutions 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.

APPENDIX II - LIST OF PARTICIPANTS

ALLEN, Robin
Director
Inter-American Tropical Tuna Commission (IATTC)
C/o Scripps Institutions of Oceanography
8604 La Jolla Shores Drive
La Jolla, CA 92037-1508, USA
Tel: (+1 858) 546 7029
Fax: (+1 858) 546 7133
Email: rallen@iattc.org

ARENAS, Pablo
Senior Scientist
Inter-American Tropical Tuna Commission (IATTC)
C/o Scripps Institutions of Oceanography
8604 La Jolla Shores Drive
La Jolla, CA 92037-1508, USA
Tel: (+1 858) 546 5695
Fax: (+1 858) 546 7133
Email: parenas@iattc.org

BAYLIFF, William
Senior Scientist
Inter-American Tropical Tuna Commission (IATTC)
C/o Scripps Institution of Oceanography
8604 La Jolla Shores Drive
La Jolla, CA 92037-1508
USA
Tel: (+1 858) 546 7025
Fax: (+1 858) 546 7133
Email: wbayliff@iattc.org

CAROCCI, Fabio
Research Assistant
Marine Resources Service (FIRM)
Fisheries Department (FI)
Food and Agriculture Organization of the United Nations (FAO)
Via delle Terme di Caracalla
00100 Rome
Italy
Tel: (+39 06) 57055176
Fax: (+39 06) 570 53020
Email: fabio.carocci@fao.org

DERISO, Richard
Chief Research Scientist
Inter-American Tropical TunaCommission (IATTC)
C/o Scripps Institution of Oceanography
8604 La Jolla shores Drive,
La Jolla, CA 92093-0203
USA
Tel: (+1 858) 546 7020
Fax: (+1 858) 546 7133
Email: rderiso@iattc.org

GROVES, Theodore
Professor
Department of Economics
University of California San Diego
9500 Gilman Drive
La Jolla CA 92093-0508
USA
Tel: (+1 858) 534 3383
Email: tgroves@ucsd.edu

HAMPTON, John
Oceanic Fisheries Programme Manager
Oceanic Fisheries Programme
Secretariat of the Pacific Community (SPC)
B.P. D5
98848 Nouméa Cedex, New Caledonia
Tel: (+687) 260 147
Fax: (+687) 263 818
Email: johnh@spc.int

JOSEPH, James
Consultant
2790 Palomino Circle
La Jolla, CA 97037, USA
Tel: (+1 858) 454 5057
Fax: (+1 858) 454 2604
Email: jjoseph@iattc.org

MAJKOWSKI, Jacek
Fishery Resources Officer
Marine Resources Service (FIRM)
Fisheries Department (FI)
Food and Agriculture
Organization of the United Nations
(FAO)
Via delle Terme di Caracalla
00100 Rome
Italy
Tel: (+39 06) 57056656
Fax: (+39 06) 570 53020
Email: jacek.majkowski@fao.org

MIYABE Naozumi
Director
Temperate Tuna Resources Division
National Research Institute of Far Seas
Fisheries
Fishery Research Agency of Japan
5 chome, 7-1
Orido, Shimizu, Shizuoka 424-8633
Japan
Tel: (+81 543) 366 6031
Fax: (+81 543) 359 642
Email: miyabe@fra.affrc.go.jp

MIYAKE, Peter
Scientific Advisor
Japan Tuna Fisheries Association
3-3-4 Shimorenjaku, Mitaka-shi
Tokyo 181-0013, Japan
Tel: (+81) 422 463 917
Fax: (+81) 422 463 917
Email: p.m.miyake@gamma.ocn.ne.jp

MORÓN, Julio
Assistant Director
Organización de Productores Asociados de
Grandes Atuneros Congeladores
(OPAGAC)
C/Ayala 54, 2 planta A
28001 Madrid, Spain
Tel: (+34) 9157 58959
Fax: (+34) 9157 61222
Email: opagac@arrakis.es

REID, Chris
Fisheries Economics Advisor
Forum Fisheries Agency (FFA)
P.O. Box 629
Honiara
Solomon Islands
Tel: (+677) 2112 4
Fax: (+677) 239 95
Email: chris.reid@ffa.int

RESTREPO, Victor
Assistant Executive Secretary
International Commission for the
Conservation of Atlantic Tunas (ICCAT)
Calle Corazón de María, 8 Planta 6
28002 Madrid, Spain
Tel: (+34) 91 416 5600
Fax: (+34) 91 415 2612
Email: victor.restrepo@iccat.int

SCOTT, Gerald P.
Director
Sustainable Fisheries Division
Southeast Fisheries Science Center
(SEFSC)
National Marine Fisheries Service
(NMFS)
National Oceanic & Atmospheric
Administration (NOAA)
75 Virginia Beach Drive
Miami – Florida 33149
USA
Tel: (+1 305) 361 4220
Fax (+1 305) 361 4562
Email: gerry.scott@noaa.gov

SQUIRES, Dale
Fisheries Economist
National Marine Fisheries Service
Southwest Fisheries Science Center
8604 La Jolla Shores Drive
La Jolla, CA 92037-1508, USA
Tel: (+1 858) 546-7003
Fax: (+1 858) 546-7113
Email: dale.squires@noaa.gov

TSUJI Sachiko
Senior Fishery Statistician
Fishery Information, Data and Statistics Unit
Fisheries Department
Food and Agriculture Organization of the United Nations (FAO)
Via delle Terme di Caracalla
00100 Rome
Italy
Tel: (+39 06) 57055318
Fax: (+39 06) 570 52476
Email: sachiko.tsuji@fao.org

WRIGHT, Andrew
Executive Director
Western and Central Pacific Fisheries Commission
P.O. Box 2356
Kolonia, Pohnpei FM 96941
Federated States of Micronesia
Tel: +691 320-1992/1993
Fax: +691 320-1108
Email: dreww@mail.fm

APPENDIX III - PROVISIONAL AGENDA

Registration: 8:30 to 9:30 on Mon., May 8, 2006
Sessions: 9:00 (with the exception of the first day – see below) to 17
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, May 8, 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

8. *[9:00]* **Feasibility of (i) routinely collecting input data for the Data Envelopment Analysis (DEA) and (ii) 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. *[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 1st 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

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 1st draft**

Note: After the completion of Agenda Item 14, the 1st draft of the Statement will be revised for its adoption on the next day (see Agenda Item 16)

15. *[16:45]* **Other matters**

Friday

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

APPENDIX IV - LIST OF PAPERS

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

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

P3 *Estimates of 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 overall US Atlantic longline fishing capacity and effort by Gerry Scott (NMFS)*

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

P6 *Review of existing information and their 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 in the Tuna Fishery with Undesirable Outputs by James Kirkley (CWM)*

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

P11 *Tuna fishing capacity: perspective of purse-seine fishing industry on factors affecting it and its management by Julio Moron (WTPO)*

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, Ted Groves, Jim Kirkley, Chris Reid and Jim Joseph*

P14 *Requirements and Alternatives for the Limitation of Fishing Capacity in Tuna Purse-Seine Fleets by Jim Joseph, Dale Squires and Ted Groves*

P15 *Vessel buyback schemes by Dale Squires (NMFS) 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, where at least one input is fixed, especially the capital stock, given the state of technology, 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. well capacity, length, gross registered tons). 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 to one, comes from not using all of the available fishing effort (variable inputs), given the fixed inputs, state of technology, environmental conditions, and 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 and 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 boats in the fleet are compared, with the “best” set of vessels used as a benchmark. The “best” boats are those that have the greatest

level of output per unit of input. These boats determine the “frontier”. DEA is a non-parametric technique, solved using a linear programming model, so cannot directly deal 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 between gear and vessel types and over time, based on total annual catch. Following Gulland (1986), 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) 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 which contribute to the production of an output. Inputs typically include capital, labor, 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 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 vessel as well as alter their fishing activity. 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 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 purchase a larger vessel.

Overcapacity

Overcapacity can be considered the generic term for excessive levels of capacity in the longer term and 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.

Overcapitalisation

Overcapitalisation refers to an actual capital stock that is in excess of that optimum capital stock required to produce some optimum output level. Overcapitalisation 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 those vessels with the highest production performance, 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 highest catch, given the harvesting technology, capital stock, resource stock, and state of technology, provide measures of full capacity. The approach is called peak-to-peak 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 to technological change 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 vessel as well as alter their fishing activity.

State of Technology

State of technology refers to the current, existing state of technical knowledge of 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 full 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/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 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. An example of a partial productivity measure is output per worker, or 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, May 8-12, 2006

This Workshop is the 3rd meeting convened by the FAO project created in response to concerns about over-capacity in tuna fisheries on the global scale. The 3rd meeting recalled and built on the conclusions and recommendations from the previous meetings.

The available evidence indicates that globally, there is more capacity than needed to achieve the management objective for most tuna stocks. Notwithstanding management measures implemented by RFMOs, over-capacity has already led to over-exploitation of some tuna stocks and it is likely to lead to over-exploitation of other tuna stocks that are near 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. Until such systems are implemented, the Workshop recommends that steps as listed below be taken to prevent further growth of fishing capacity.

Such systems should take into consideration the right of individual vessel owners to transfer the capacity of their vessels between different countries participating in the RFMO and make provision for the replacement of existing capacity, while ensuring 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 assure transparency and to assure accuracy of the information bases from which conclusions are drawn. Global coordination is needed to prevent spillover of overcapacity from one region to another.

The Workshop recommends that interim Management 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 fleet and its activity, to facilitate control of fishing capacity regionally and globally,
5. collection of information on activity of vessels that are currently not monitored, by States, fishing entities and RFMOs,
6. limited entry to regional registers of vessels that fish for tunas that in combination provide a global register,
7. use of buyback or similar incentives to reduce any over capacity,
8. assurance of the rights of participants in the fishery and incentives for their contribution 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 should 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.