TECHNICAL AND COMPLIANCE COMMITTEE
Fifth Regular Session
1-6 October 2009
Pohnpei, Federated States of Micronesia

MONITORING AND MEASURING FISHING CAPACITY IN THE WCPO

WCPFC-TCC5-2009/23
16th September 2009

Paper prepared by the Secretariat[1]

Introduction

1. Paragraph 44 of Conservation and Management Measure (CMM) 2008-01 states:

> *Drawing on work that has been completed by CCMs, the Commission Secretariat shall present a report on measuring and monitoring fishing capacity in the Western and Central Pacific Ocean for consideration at the Fifth Regular Session of the Technical and Compliance Committee.*

2. Circular 2009/14, which was distributed on 4th June 2009, invited CCMs to provide details of work completed in respect of the measurement of monitoring of fishing capacity in the Western and Central Pacific Ocean (WCPO). In addition, CCMs were invited to contribute to this task during consideration of scientific issues associated with capacity at the Fifth Regular Session of the Scientific Committee, 10-21 August, Port Vila, Vanuatu. Although no responses were received several studies of capacity in WCPO tuna fisheries have been commissioned over the years. The resulting reports of some of these studies have been drawn on for this report.

Conceptual issues and background

3. The term "fishing capacity" is still interpreted in different ways by different fishery stakeholders. The 2004 FAO report on the State of World Fisheries and Aquaculture notes:

> *"……..Fishing technologists often consider fishing capacity as the technological and practical feasibility of a vessel achieving a certain level of activity – be it days fishing, catch or processed products. Fisheries scientists often think of fishing capacity in terms of fishing effort, and the resultant rate of fishing mortality (the proportion of the fish stock killed through fishing). Fisheries managers generally have a similar view of fishing capacity, but often link the concept directly with the number of vessels operating in the fishery. Many managers express fishing capacity in measures such as gross tonnage or as total effort (e.g. standard fishing days*

[1] This paper benefitted from comments generously provided by Dale Squires in his capacity as an independent economist. His comments did not reflect the views of his employer or the position of the US Government. Dr Chris Reid also kindly reviewed the document.

available). Most of these ideas reflect an understanding of capacity primarily in terms of inputs (an input perspective). In contrast, economists tend to consider capacity as the potential catch that could be produced if the boat were to be operating at maximum profit or benefit (an output perspective). To reflect these different views of fishing capacity, an FAO technical consultation developed a definition of fishing capacity that is both input (e.g. effort, boat numbers, etc.) and output (catch) based:

> *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* (FAO 2004).

4. So fishing capacity is a multidisciplinary concept. It covers biological, social, economic and technological issues with the result that measuring and monitoring capacity, and any associated analysis, is often difficult and complex.

5. Section 6 of the 1995 FAO Code of Conduct for Responsible Fisheries calls on States to conduct assessments of capacity with a focus on identifying excess capacity in fisheries. The 1997 session of the FAO Committee on Fisheries (COFI) recommended that FAO convene a series of technical meetings to address the issues of defining, measuring, and controlling fishing capacity. Subsequently FAO organized a Technical Working Group on fishing capacity and this led to the development of an International Plan of Action (IPOA) for the Management of Fishing Capacity adopted in 1999. The IPOA-Capacity calls on regional fisheries bodies and States to achieve an efficient, equitable, and transparent scheme for management of fishing capacity worldwide (FAO, 1999).

6. For the purposes of developing a National Plan of Action for the Management of Fishing Capacity (NPOA-Capacity), FAO recommended that States adopt a national definition of fishing capacity. To support this, the 1999 FAO Technical Consultation recognized that capacity can be estimated either on an input or output basis so, for the purpose of international comparison, it was recommended that States express their national estimates on both bases, removing the need to agree on a common definition when the management of fishing capacity involves international cooperation. Since then, FAO and others have invested considerable resources in researching fishing capacity (e.g. Gréboval, 1999; Cunningham and Gréboval, 2001; Joseph, 2003; Pascoe *et al*., 2003; Pascoe *et al.*, 2004; Ward *et al.*, 2004).

7. Fishing capacity refers to the capability to catch fish. In one concept of capacity, it can be defined as the maximum amount of fish, over a period of time, that can be produced by a vessel or fleet of vessels if fully utilized, given the biomass and age structure of the fish stock and the present state of the technology (FAO, 1998). This definition provides broad guidance on the information requirements for measuring and monitoring capacity: measurement of catch, effort, the applicable time period, physical vessel and fleet details, operational information (areas, technology), biological characteristics of the resource and stock condition.

8. Kirkley and Squires (1999) discussed two concepts of capacity – an economic interpretation and a primal interpretation. The economic concept is defined according to short-run economic optimization (e.g. cost minimization, revenue maximization or profit maximization) while the primal concept ignores economic optimization but implicitly incorporates economic behavior through empirical observation (Walden *et al.* in press). Economic concepts of capacity are more informative and are generally used by most governments to measure relative performance in other industrial sectors. However, it is difficult to apply economic concepts to fisheries because of the absence of necessary data (e.g. fuel, labour, and the costs of capital services, etc.) with the result discussion of fisheries capacity is generally restricted to physical (primal) concepts such as vessel numbers, tonnage, etc.

Input-based measures

9. A range of capacity indicators, mostly based on physical attributes of the fleet, have been applied in world fisheries. Key indicators include input measures such as gross tonnage, engine power and the number of boats. Measures that consider only the capital stock (however measured) ultimately are considering capital utilization. When the variable inputs are considered as well, capacity utilization also comes into play. Almost invariably, input measures of capacity and capacity utilization are actually measures of capital and capital utilization, not capacity and capacity utilization (Squires, *pers. comm.*)

10. Input-based measures involve an implicit assumption that the level of output is related to the level of physical inputs in the fishery. If these inputs were fully utilized, then the capacity of the fleet would be a function of these inputs. The level of utilization relates to the ratio of present capacity to present production. Hence, capacity is assumed to be a function of boat size, engine power, etc., on the assumption that they are fully utilized. However, as early as 1999 it was demonstrated that fishing capacity should not be viewed as a proxy for fishing effort (Kirkley and Squires, 1999). Changes in effort levels do not necessarily change the potential output of the fleet and so do not directly affect the capacity (just capacity utilization) [2].

11. Input-based capacity involves more than just the vessel or boat used to harvest fish. Labour as well as capital and the status of the stock or stocks of fish also need to be considered when developing input-based capacity measures. FAO's *Technical Consultation on the Measurement of Fishing Capacity* (FAO Fisheries report 615) identified four input-based levels of information for monitoring capacity, the level of information determining the methods that can be used measure and assess capacity. A summary of information that can be measured and used to monitor capacity is summarized in Table 1.

Output-based measures

12. Government agencies, when considering macroeconomics and the state of the overall economy, including inflationary pressures, invariably use an output-based measure determined by surveys of corporations that assess potential output under normal operating conditions and circumstances. Fisheries is one of the few instances in which input-based measures, particularly measures of the capital stock, receive so much consideration (Squires, *pers. comm.*).

13. Output-based measures relate to the potential level of output of a fleet and/or the level of capacity utilization directly, usually at the individual vessel level. Implicit in the estimation of the output-based capacity measure is also a relationship between the level of fixed inputs, their level of utilization and the level of output - subject to resource status, its composition and distribution, the technology available, environmental conditions and normal operating procedures (including social norms) (Squires *pers. comm.*).

[2] FAO Fisheries Technical Paper No. 433/1 *Measuring and assessing capacity in fisheries. 1. Basic concepts and management options (Ward et al. 2004).*

Table 1. Information necessary for monitoring and assessing capacity in tuna fisheries [adapted from *Technical Consultation on the Measurement of Fishing Capacity*, FAO Fisheries Report 615]

Level	Information
1	An estimate of total landings: • An estimate of total vessels; • In non-vessel-based (artisanal/subsistence) fisheries, number of participants or a measure of the total gear units in use (e.g. total number of beach nets).
2	As for Level 1, plus: • an index of vessel size and/or power; • gear type; • a "rough" index of trends in fishing success; • "rough" measures current effort and maximum effort that could be deployed in the fishery; • basic characteristics of fishing operations (e.g. seasonality, number and types of fisheries in which vessels operate, species targeting trends, use of fish aggregating and fish finding devices such as fish aggregating devices or FADs, sonar, satellite tracking, other examples of changes in technology, autonomy of vessels, trans-shipment practices).
3	As for Level 2, plus: • total catch (including discards) split by fleet/gear and by species; • basic biological information (e.g. resource distribution, catch by species, size structure, estimates of potential maximum sustainable yield); • comprehensive primary characteristics determining fishing power (e.g. gross tonnage or other volume measures, engine power, fish hold capacity, vessel age); • comprehensive information on gear characteristics, type and dimensions; • prices or revenues by major species; • detailed effort and catch per unit of effort (CPUE) data, including time spent fishing.
4	As for Level 3, plus: • detailed biological information on fish stocks (e.g. estimated biomass, fishing mortality rates, age/size structure, uncertainty in stock assessments); • comprehensive data on other important features of the fishery such as detailed information on fish aggregating and finding devices (e.g. sonar, FADs, satellite tracking), skipper and crew skill levels, fuel consumption, autonomy of vessels, processing capacity, cost and earnings information, value of capital stock, employment, subsidies and economic incentives, and fishing operations relative to fish distributions.

14. Methods used to determine fishing capacity include peak-to-peak, stochastic production frontiers and data envelopment analysis which use catch and input information for individual vessels to estimate capacity utilization and technical efficiency (see *FAO Fisheries Technical Paper No. 433/2).* As noted in *Technical Guidelines for Responsible Fisheries* No. 4, these different ways of measuring capacity often generate very different estimates - which is indicative of capacity assessment difficulties.

15. The link between the level of inputs and the level of outputs is generally the basis for management of fisheries using input controls. Changing the level of inputs (e.g. through buyback) or their utilization (e.g. through days at sea restrictions, seasonal closures) is assumed to have a proportional effect on the level of output – again subject to resource biomass availability and distribution, technology availability, environmental conditions, etc. However, even in single species fisheries, the relationship between levels of input and levels of output is often not proportional (linear). Multi-species, multi-gear fisheries are more complex. Changes in the distribution of the inputs can have a substantial effect on the output in a fishery even if the total input-based "capacity" is unchanged.

Work elsewhere

Eastern Pacific[3]

16. Past efforts to monitor capacity in the Eastern Pacific Ocean (EPO) have been based on measured well volume or carrying capacity. This carrying capacity increased rapidly during the early 1970s, reaching 196,500 m^3 in 1980-1981. It then decreased to 121,650 m^3 in 1984, and remained at an average of about 135 000 m^3 until the mid-1990s, when it began to increase again. The fleet carrying capacity was 182 000 m^3 in 1999, and increased to 213 000 m^3 by the end of 2005 stabilizing at around 228,000 m^3 since 2006.

17. IATTC established a Working Group on Limiting the Growth in Capacity of the Purse-Seine Fleet in the Eastern Pacific Ocean (later known as the Permanent Working Group on Fleet Capacity) in 1998. The WG reviewed a report *Considerations Regarding Limiting the Growth in Capacity of the International Tuna Purse-Seine Fleet in the Eastern Pacific Ocean* prepared for that meeting, based mostly on yellowfin tuna stock assessments. It concluded that 135,000 metric tons carrying capacity in the fleet generates the fishing effort or mortality required to catch the average maximum sustainable yield (AMSY) of yellowfin and the recommended catch of bigeye from the EPO. It was also considered capable of generating the amount of fishing effort that produced the highest catch of all species combined in the history of the fishery."

18. As a result of the standardization of well volumes in the Regional Vessel Register of the IATTC, the figure of 135,000 tonnes was converted into 158,000 m^3, using a multiplier of 1.17, and this rounded figure has been used since 1999 in various documents and resolutions of the IATTC as the maximum target carrying capacity for the purse-seine fleet.

19. This target figure of 158,000 m^3 has been reviewed and discussed at many IATTC meetings to take into account developments in the fishery since 1998, particularly the increased catches of skipjack tuna. The 69th meeting of the IATTC in June 2002 endorsed a target carrying capacity of 158,000 m^3 in its *Resolution on the Capacity of the Tuna Fleet Operating in the Eastern Pacific Ocean (Revised)*. This was supplemented by the *Plan for Regional Management of Fishing Capacity* of June 2005. Both of these instruments rely upon the vessel register established by the *Resolution on a Regional Vessel Register* of June 2000, and the *Resolution on the Establishment of a List of Longline Fishing Vessels over 24 Meters (LSTLFVs) Authorized to Operate in the Eastern Pacific Ocean* of June 2003.

20. The issue of establishing a target capacity for the EPO longline fleet is a more recent one. The 11th meeting of the Permanent Working Group on Fleet Capacity in 2004 requested that the fifth meeting of the Working Group on Stock Assessment in 2004 discuss target capacities for both the purse-seine and longline fleets. The group concluded that the 158 000 m^3 limit seemed appropriate for the purse-seine fleet, from the point of view of optimizing the purse-seine fishery for yellowfin tuna.

21. The group looked also at the suitability of several methods for the control of longline capacity, and concluded that, given management trade-offs and the factors affecting the various tuna fisheries, and considering the potential increase in fishing power of the fleets, the optimal capacity for both components

[3] Based on: Arenas, P. 2007. Estimated target fleet capacity for the tuna fleet in the eastern Pacific Ocean, based on stock assessments of target species. In: Methodological workshop on the management of tuna fishing capacity - Stock status, data envelopment analysis, industry surveys and management options. La Jolla, California, United States of America, 8-12 May 2006, pp. 39-50. Ed. by B.H. Bayliff and J. Majkowski. FAO.

of the tuna fleet would continue to be a moving target. The 72nd IATTC meeting in 2004 endorsed these views. As a result a target capacity for the longline fleet has not been established. Catch limits are applied in the 2005 yellowfin and bigeye conservation resolution and these have been revised and carried in the 2009 Resolution adopted by the Commission.

Atlantic Ocean[4]

22. Despite the fact that ICCAT established limits on fishing effort in the 1990s, the ICCAT Secretariat considered that more comprehensive and scientifically defensible approach to assess and manage capacity within the ICCAT region was required. The majority of the early capacity limitation recommendations were adopted in a relatively *ad hoc* manner that simply sought to cap the capacity of the fleets targeting the various tuna stocks, or reduce the capacity to a predetermined historic level.

23. In 2006, ICCAT established a Working Group on Capacity with the following terms of reference (ICCAT 2007b):

a. to determine by fishery the availability of the data required to assess fishing capacity and appropriate methodologies to measure fishing capacity based on available data;
b. to review and assess the level of fishing capacity for ICCAT managed species by country/ fleet/gear/fishery in light of the status of the resources, as indicated in SCRS assessments with a priority focus on bluefin tuna, including caging activities;
c. to review the CPUE data and other relevant information in order to evaluate the relationship between capacity levels and available fishing possibilities;
d. In light of the outcomes of points 1(a)-(c) above, the Working Group may, if necessary, develop guidelines for managing fishing capacity in ICCAT fisheries for consideration by the Commission, *inter alia*, taking into account the needs of developing countries while ensuring the sustainable and equitable use of tuna and tuna-like resources.

24. The Working Group met twice; once in 2007 and again in 2008. The first meeting dealt primarily with the collation and identification of available data with which to assess capacity and to achieve a consensus amongst ICCAT Parties on the definition of capacity and the methods with which it could be assessed by fishery (ICCAT, 2007a). The second meeting identified gaps in data needed for capacity assessment as well as the need to agree to short term objectives for specific high priority fisheries (such as bluefin tuna). The meeting also attempted to identify long term work programmes needed to address capacity (ICCAT 2008a).

25. The Commission also requested that the Standing Committee on Research and Statistics (SCRS) to undertake an evaluation of the fishing capacity for the different fleets/gears that participate in the various fisheries with a view to establishing effective fishing effort correlation with capacity (ICCAT 2007c). Additional work on capacity was carried out by the Working Group on Stock Assessment Methods (WGSAM) in 2007 and 2008. The group recognised the fact that no universal definition of capacity exists, and that a concept of capacity will differ according to the expertise of those assessing it (e.g. stock assessment scientists may have a different concept of capacity from fisheries managers). This was reiterated by the group in 2008 at which stage it was decided to produce a list defining the different terms suggested during the 2007 meeting (ICCAT 2007c). The WGSAM also identified that the long-term productivity of a stock is greatly influenced by the changes in selectivity of the fleets that exploit it. This was considered to be particularly applicable to tuna, where the relative importance of different

[4] Based on: Murua, H., de Bruyn, P. and Arrizabalaga, H. *A review of the ICCAT experience on tuna fishing capacity assessment and management* Indian Ocean Tuna Commission Science Committee, IOTC-2008-SC-08

fisheries utilizing different gears (with different selectivity) can change over time. The group also acknowledged that it is complicated to assess capacity over a range of different gears and species because the scale of information available for stock assessments is usually on a single species level.

26. Murua *et al*. (2008) conclude that estimating fishing capacity is complex, as the fishing capacity depends on many variables (number of boats, size of boats, fishing time, efficiency, etc.) that are not routinely collected. Estimation of tuna fishing capacity can be problematic not only because a lack of data, but also because of fleets migration between oceans (or different parts of the same ocean), rapid switching of target stock, or because of the multispecies nature of some (e.g. purse seine) fisheries (as the optimum capacity for different species might differ), or because different gears (e.g. longline and purse seine) operate on the same stock and the optimum capacity of the former depends on the capacity of the latter (Arenas 2007).

Indian Ocean

27. The 2008 session of the IOTC Scientific Committee to assist discussions on fishing capacity[5]. The Secretariat reported that IOTC capacity in the Indian Ocean is currently documented in the form of i) a list of authorized vessels, ii) a list of active vessels reported by contracting parties for the previous year, and iii) fishing craft statistics (numbers by category). The Secretariat also noted that details for vessel characteristics are incomplete (e.g. no information on well size, vessels report either GT or GRT – but not consistently one or the other, etc.).

28. The Scientific Committee concluded that limiting fishing capacity alone is inadequate to provide management of fish stocks particularly at the RFMO scale. It considered that capacity controls require action at the global level. In its view there remain significant questions about how to reduce current excess capacity as any measure cannot be applied to only one part of the total fleet - it must be applied across all vessel gear types.

29. While it was noted that the best outcomes from capacity limitation would be achieved if it was implemented at the global level, and that the establishment of such controls would facilitate alternative local (RFMO) management actions (e.g. based on quotas), the Scientific Committee agreed that it was important to explore what each RFMO could do to add value to the existing studies and provide to the information needed by the Commission. To contribute to this the 13th Session of the IOTC established a Working Party on Fishing Capacity Analysis which is to work over several years to consider the needs and potential role of capacity management in the Indian Ocean. While not focusing on the estimation of fishing capacity, but also providing information on the implementation of capacity controls, the Terms of Reference for the Working Party are:

- Review methods reviewed by the FAO Technical Advisory Committee on Tuna Fishing Capacity and by other RFMOs, national management bodies, and other institutions to estimate and manage fishing capacity;
- Investigate the most suitable methods currently available to determine fishing capacity that can be applied in the Indian Ocean. Review any additional data requirements to apply to those methods in IOTC;
- Define the factors affecting fishing capacity that can be managed by IOTC;

[5] IOTC-2008-SC-08, INF01, INF02, INF03, INF04, INF05, INF08, and INF30.

- Determine the fishing capacity of the existing tuna fishing fleets relative to the status of the resources; and
- Determine the relative fishing capacities of different vessel/gear categories.

30. Current IOTC Resolutions dealing with capacity (Resolutions 07/05 and 06/06) equates capacity to number of vessels. For example, Resolution 06/05 on the Limitation of Fishing Capacity in Terms of Number of Vessels of IOTC Contracting Parties and Cooperating Non-Contracting Parties states: "CPCs shall limit the number of their vessels by gear type, of 24 m overall length and over, and under 24 m if they fish outside their EEZ, fishing for tropical tunas in the IOTC area……."

Previous work in the WCPO

Purse seine

31. In 2003 the National Marine Fisheries Service arranged for a study of issues associated with understanding capacity and capacity changes in the Western and Central Pacific Ocean (WCPO) purse seine fishery during the previous 15 years[6]. The study noted that the assessment of carrying capacity in the WCPO could only be broadly estimated because of:

- poor verifiable requisite individual vessel data from both national and regional vessel registries;
- the lack of a standard metric to measure capacity; and
- limited understanding of the dynamics of different WCPO purse seine fleets which impact on an ability to determine the relationship between proxies for carrying capacity and actual fishing capacity[7].

32. The study concluded that:

The carrying capacity of a tuna purse seiner appears to be an imperfect indicator of the ability to catch fish. Due to special operational characteristics of some of the major purse seine fleets in the WCPO region, the use of carrying capacity as a proxy appears less suitable than in the Eastern Pacific Ocean region where the concept was developed for tuna purse seiners which typically discharge full fish loads. Although the use of carrying capacity as a proxy has its shortcomings, especially in the WCPO, there are no obvious alternatives. Carrying capacity therefore appears to be presently the best of a number of imperfect options (such as tonnage, length, crew size) for measuring fishing capacity of tuna purse seine vessels.

33. Reid *et al.* (2003) and Reid *et al.* (2006) analyzed tuna purse-seine fishing capacity in the WCPO using DEA. The analyses, conducted at the vessel level for the period 1998-2002, accommodated recent fleet configurations, cost conditions, fishing patterns and potential shifts in capacity output due to

[6] Gillett, R. and Lewis, A.D. 2003. *A Study of Purse Seine Fishing Capacity in the Western and Central Pacific Ocean 1988-2003.* A report commissioned by the US National Marine Fisheries Service.

[7] 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 (IOTC-2008-SC-INF02).

technical change and skipper skill levels. On the basis of the data available, the conclusion of the analysis was that fishing capacity for skipjack, yellowfin and bigeye, purged for technical efficiency, exceeded actual catch levels in the period 1998-2002.

Longline and pole and line

34. In 2006 NMFS supported a companion study to determine longline and pole and line fleet capacity in the WCPO in 2005[8]. The purpose of the study was to provide:

- An estimate of WCPFC area longline and pole-and-line vessel fleet sizes;
- A capacity-oriented classification system for longline and pole-and-line vessels;
- National fleet profiles, including documentation of past and present participation of the various fleets in the WCPFC area; and
- Identification of significant constraints in obtaining a more precise (output) estimate of longline and pole-and-line fishing capacity in the region.

35. The study estimated national longline and pole/line fleet sizes and concluded that estimates of vessel numbers could be improved considerably by obtaining the full cooperation of major distant water fleets, gaining a greater understanding of longliners based in Indonesia and Vietnam, and revising the WCPFC vessel detail reporting requirements. The authors concluded that going beyond fleet sizes to obtain an output-oriented estimate of fishing capacity (potential annual catch) appeared possible but more information on vessel characteristics and catch rates (including disaggregated data for the high seas) are required.

General

36. Hampton (2006) concluded that 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 input capacity limits, or, indeed, other broadly-specified effort-based measures, to equally address the stock status of all species simultaneously. He noted that "effort creep" is also a significant factor 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". 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 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 be influenced by capacity in other components.

37. Information for the purse seine fleet active in the WCPO, on both the high seas and in waters under the national jurisdiction of FFA member countries, has improved since these two studies were undertaken partly as a result of developments in satellite-based vessel monitoring. However, while

[8] Gillett, R. and McCoy, M. 2006. *Report of a Study to Establish the Capacity of Longline and Pole and Line Fleets in the Western and Central Pacific Ocean*. A report commissioned by the US National Marine Fisheries Service.

information on vessels active has improved, the data available from national or regional vessel registries, particularly the WCPFC Record of Fishing Vessels, remain inadequate as sources of reliable information to measure fishing capacity. In most instances this is not because those registries do not require the necessary information. In the case of the WCPFC Record of Fishing Vessels it is generally related to i) a lack of compliance by flag State CCMs with the provision of the vessel-specific information provided for in the WCPF Convention and Measures adopted by the Commission, and ii) the use of different metrics by different flag State CCMs for capacity-related vessel data that is provided to the Commission Secretariat. If fishing capacity is to be monitored in the WCPO rectifying these information shortcomings is a necessary first step.

Summary of key considerations

38. Factors that contribute to the complexity of monitoring and measuring capacity include:

- The lack of a common understanding of the term "fishing capacity" is responsible for at least some degree of confusion among the various groups of fishery stakeholders;
- Poorly articulated objectives (purpose) for the reason(s) to monitor capacity;
- due to technological, environmental, investment in capital stock and other changes including operational changes, capacity is a short-run concept and data used to measure capacity inherently requires regular updating (monitoring);
- poor availability of disaggregated operational level data for each vessel and gear type throughout the range of the fishery (within EEZs and on the high seas);
- related to the previous point, the diversity of fishing vessels (small scale subsistence and artisanal to large super seiners) and associated details of vessel characteristics/metrics - generally poor data with a common or convertible metric, for measuring and monitoring vessel capacity;
- the dynamics of tuna fleets including the migration of fleets between oceans, measurement of skipper skill and changes in vessel harvesting efficiency associated with technological developments and fishing methodologies;
- the inter-relationship between fishing capacity in different components of the fishery associated with the relative contribution of different gear types, and their impact on size selectivity, producing different outcomes for stock status and productivity estimates; and
- the multispecies nature of tuna fisheries and the differential status of target stocks.

Advice and recommendations

39. The Technical and Compliance Committee is invited to consider advice and recommendations to the Commission in relation to:

- The objective and purpose for monitoring and measuring capacity in the WCPO;
- If it is determined that there is a role for capacity measurement and monitoring to assist in the management of WCPO tuna fisheries advise on associated information requirements, responsibilities and potential associated work plan;
- Agree to data fields and standardization of metrics for the information required for CMM 2004-01: the WCPFC Record of Fishing Vessels; and

- Commit to the provision of complete information for each field specified in CMM 2004-01 relating to the WCPFC Record of Fishing Vessels.

References and further reading

Anon. 2007. Workshop to Further Develop, Test and Apply a Method for the Estimation of Tuna Fishing Capacity from Stock Assessment-Related Information. La Jolla, California. 17pp

Arenas, P. 2007. Estimated target fleet capacity for the tuna fleet in the eastern Pacific Ocean, based on stock assessments of target species. In Methodological workshop on the management of tuna fishing capacity - Stock status, data envelopment analysis, industry surveys and management options. La Jolla, California, United States of America, 8-12 May 2006, pp. 39-50. Ed. by B.H. Bayliff and J. Majkowski. FAO.

Arrizabalaga H., V.R. Restrepo, M. Maunder and J. Majkowski. 2008. Using stock assessment information to assess fishing capacity of tuna fisheries. *Submitted.*

Arrizabalaga, H., Restrepo, V. R., Maunder, M. N., and Majkowski, J. 2009. Using stock assessment information to assess fishing capacity of tuna fisheries. – ICES Journal of Marine Science, 66: 000–000.
Ballard, K. and Blomo, V**.** 1978. Estimating the structure of capacity utilization in the fishing industry. *Mar. Fish. Rev.*, **40(8)**: 29-34.

Ballard, K. and Roberts, J. 1977. Empirical estimation of the capacity utilization rates of fishing vessels in 10 major Pacific fisheries. Washington, DC: National Marine Fisheries Service.

Bayliff, W.H.; Leiva J.I., and Majkowski, J. (eds.) 2005. Second meeting of the Technical Advisory Committee of the FAO project. Management of tuna fishing capacity: conservation and socio-economics, 15-18 Mar. 2004 Madrid, Spain. *FAO Fisheries Proceedings. No*. 2. Rome, FAO. 247pp.

Bayliff, W.H.; Majkowski, J. (eds.) 2007. Methodological Workshop on the Management of Tuna Fishing Capacity: Stock Status, Data Envelopment Analysis, Industry Surveys and Management Options. La Jolla, California, United States of America, 8–12 May 2006. FAO Fisheries Proceedings. No. 8. Rome, FAO. 218pp. Bayliff, W.H.; Leiva J.I., and Majkowski, J. (eds.) 2005. Second meeting of the Technical Advisory Committee of the FAO project. Management of tuna fishing capacity: conservation and socio-economics, 15-18 Mar. 2004 Madrid, Spain. *FAO Fisheries Proceedings. No. 2*. Rome, FAO. 247pp.

Beddington J. R., D. J. Agnew, and C. W. Clark. 2007. Current Problems in the Management of Marine Fisheries. *Science*. Vol. 316: 1713-1716.

Branch, T.A., Hilborn, R., Haynie, and A.G. et al. Fleet dynamics and fishermen behavior: lessons for fisheries managers. *Canadian Journal of Fisheries and Aquatic Sciences,* 63: 1647-1668.

Cunningham, S. and Gréboval, D. (eds), 2001 Managing Fishing Capacity: A Review of Policy and Technical Issues. Rome: *FAO Fish. Tech. Pap. N*º 409.

FAO 1998. Report of the technical working group on the management of fishing capacity. La Jolla, California, United States, 15-18 April 1998. *FAO Fisheries Report*, 586: 57 pp

FAO. 1999. International Plan of Action for the Management of Fishing Capacity. FAO, Rome.

FAO. 2000. Report of the Technical Consultation on the Measurement of Fishing Capacity. *FAO Fisheries Report No*. 615. Rome.

FAO. 2006. The State of World Fisheries and Aquaculture (SOFIA), 2006. FAO, Rome.

Fare, R., S. Grosskopf, and E.C. Kokkelenberg, 1989. Measuring Plant Capacity, Utilization and Technical Change: A Nonparametric Approach. *International Economic Review*, Vol. 30, No.3.

Fare, R., Grosskopf, S. and Lovell, C.A.K. 1994. *Production Frontiers*, Cambridge, U.K., Cambridge University Press.

Gréboval, D. (ed.) 1999. Managing Fishing Capacity: Selected Papers on Underlying Concepts and Issues.Rome: *FAO Fish.Tech. Pap. Nº* 386

Hampton, J. 2006. Estimates of large-scale purse seine and longline fishing capacity in the western and central Pacific Ocean based on stock assessments of target species. Methodological Workshop on the Management of Tuna Fishing Capacity: Stock Status, Data Envelopment Analysis, Industry Surveys and Management Options. La Jolla, California, United States of America, 8–12 May 2006. FAO Fisheries Proceedings. No. 8. Rome, FAO. 218pp.

Hsu, T. 2003. Simple capacity indicators for peak to peak and data envelopment analyses of fishing capacity. *In* S. Pascoe & D. Gréboval, (eds). Measuring Capacity in Fisheries: Papers Submitted to the Technical Consultation on the Measurement of Fishing Capacity. *FAO Fisheries Technical Report. No*. 443, pp 233-260. Rome. 314 p.

ICCAT. 2001. Report for biennial period, 2000-01 PART I (2000) - Vol. 2 English version. SCRS report of 2001.

ICCAT. 2006. Report of the 2006 Atlantic Bluefin Tuna Stock Assessment Session (Madrid, June 12 to 18, 2006).

ICCAT. 2007a. Report of the 1st Meeting of the Working Group on Capacity. ICCAT report Doc. No. CAP-013B/2007. Madrid, Spain. 32pp.

ICCAT. 2007b. Compendium. Management Recommendations and Resolutions Adopted by ICCAT for the Conservation of Atlantic Tunas and Tuna-Like Species. Unpublished ICCAT report ACT-COMP-2007. Madrid, Spain. 219 pp

ICCAT. 2007c. Report of the 2007 Meeting of the Working Group on Assessment Methods. ICCAT report. Madrid, Spain - March 19 to 23, 2007.

ICCAT. 2008a. Report of the 2nd Meeting of the Working Group on Capacity. ICCAT report PLE-101/2008. Madrid, Spain. 20pp.

ICCAT. 2008b. Report of the 2008 Meeting of the Working Group on Assessment Methods. ICCAT report. Madrid, Spain - February 18 to 22, 2008.

ICCAT. 2008c. Report of the 2008 Atlantic Bluefin Tuna Stock Assessment Session (Madrid, June 23 to July 4, 2008).

Joseph, J. (Ed.) 2003 Managing Fishing Capacity of the World Tuna Fleet. Rome: *FAO Fish. Circ*. Nº 982.

Kirkley, J. and Squires, D. 1999a. Measuring Capacity and Capacity Utilization in Fisheries, in D. Gréboval (Ed.) Managing Fishing Capacity. *FAO Fisheries Technical Paper No*. 386. FAO, Rome.

Kirkely, J. and Squires D., 1999b. Capacity and capacity utilization in fishing industries. Discussion Paper 99-16, Department of Economics, University of California at San Diego. La Jolla.

Kirkley, J.E., Fare, R., Grosskopf, S., McConnell, K., Squires, D.E. and Strand, I. 2001. Assessing capacity and capacity utilization in fisheries when data are limited. *North American Journal of Fisheries Management* 21, 482–497.

De Leiva Moreno J. I. and J. Majkowski. 2004. Status of tuna resources. SCTB17 Working Paper INF-SA-2. 17th Meeting of the SCTB.

Maunder, M.N. and Punt, A.E. (2004) Standardizing catch and effort data: a review of recent approaches. *Fisheries Research* 70, 141–159.

McCluskey and Lewison, 2008. Quantifying fishing effort: a synthesis of current methods and their applications. *Fish and Fisheries* 9:188-200.

Miyake, P.M., 2005 A review of the fishing capacity of the longline fleets of the world *In*: 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 Socioeconomics". Madrid, Spain, 15-18 March 2004. *FAO Fisheries Proceedings. No*. 2. Rome, FAO. 2005. pp. 157-170.

Morrison, C.J. 1985. Primal and dual capacity utilization: An application to productivity measurement in the U.S. automobile industry. *Journal of Business and Economic Statistics* 3(4): 312-334.

Murua, H., de Bruyn, P. and Arrizabalaga, H. 2008. *A review of the ICCAT experience on tuna fishing capacity assessment and management.* Indian Ocean Tuna Commission Science Committee, IOTC-2008-SC-08

Nelson, R. 1989. On the measurement of capacity utilization. *Journal of Industrial Organization* 33: 51-74

Pascoe, S., Kirkley, J.E., Gréboval, D. and Morrison-Paul, C.J. 2003 Measuring and assessing capacity in fisheries 2. Issues and methods.Rome: *FAO Fish. Tech. Pap. Nº* 433/2. Rome. 130p.

Pascoe, S., Gréboval, D., Kirkley, J. and Lindebo, E. (eds), 2004 Measuring and appraising capacity in fisheries: framework, analytical tools and data aggregation. Rome: *FAO Fish. Circ*. Nº 994.

Reid, C., Squires, D., Jeon, Y.G., Rodwell, L. and Clarke, R. 2003. An analysis of fishing capacity in the western and central Pacific Ocean tuna fishery and management Implications. *Marine Policy*, 27, 449–469.

Reid, C., Kirkley, J.E., Squires, D. and Ye, J. 2005. An analysis of the fishing capacity of the global tuna purse-seine fleet *In*: 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. 117-156.

Reid, C. and Squires, D. 2006. Measuring fishing capacity in tuna fisheries: Data Envelopment Analysis, industry surveys and data collection. Methodological Workshop on the Management of Tuna Fishing Capacity: Stock Status, Data Envelopment Analysis, Industry Surveys and Management Options. La Jolla, California, United States of America, 8–12 May 2006. *FAO Fisheries Proceedings.* No. 8. Rome, FAO. 218pp.

Restrepo V. R. 2001. Notes on the estimation of fishing effort correspondence for albacore fisheries. ICCAT SCRS/00/107.

Restrepo V.R. 2007. Estimates of large-scale purse-seine, baitboat and longline fishing capacity in the Atlantic Ocean: an analysis based on a stock assessment of bigeye tuna. *In* W.H. Bayliff and J. Majkowski, eds. Report of the Methodological Workshop on the Management of Tuna Fishing Capacity: Stock Status, Data Envelopment Analysis, Industry Surveys and Management Options, *FAO Fish. Proceedings* No. 8: 51-62, Rome.

Segerson, K. and Squires, D. 1990. On the Estimation of Economic Capacity Utilization. *Journal of Econometrics*, Vol. 44 (3), pp. 347-361.

Squires, D., Kirkley, J., Joseph, J., Groves, T. and Reid, C. 2007. Relating estimates of fishing capacity obtained from Data Envelopment Analysis to traditional measures of fishing capacity. *In* W.H. Bayliff and J. Majkowski, eds. Report of the Methodological Workshop on the Management of Tuna Fishing Capacity: Stock Status, Data Envelopment Analysis, Industry Surveys and Management Options, *FAO Fish. Proceedings* No. 8: 51-62, Rome.

Ward, J.M., Kirkley, J.E., Metzner, R. and Pascoe, S. 2004. Measuring and assessing capacity in fisheries. 1. Basic concepts and management options. *Fish. Tech. Pap. Nº* 433/1 Rome. 40p.

Yew, T.S. and Heaps, T. 1996. Effort dynamics and alternative management policies for the small pelagic fisheries of Northwest Peninsular Malaysia. *Marine Resource Economics* 11, 85–103.