

Report of the

**TECHNICAL CONSULTATION ON THE MEASUREMENT
OF FISHING CAPACITY**

Mexico City, Mexico, 29 November - 3 December 1999



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PREPARATION OF THIS DOCUMENT

This is the final version of the report as approved by the Technical Consultation on the Measurement of Fishing Capacity, Mexico City, Mexico, 29 November - 3 December 1999.

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ABSTRACT

The Technical Consultation on the Measurement of Fishing Capacity was held in Mexico City, Mexico, from 29 November to 3 December 1999. It was attended by delegations from 56 Members of FAO and by observers. The Consultation examined measurement issues in relation to the implementation of the International Plan of Action for the Management of Fishing Capacity adopted by the Twenty-third Session of the FAO Committee on Fisheries in February 1999. Twenty-six technical papers were presented at the Consultation to serve as a basis for further deliberations. Discussions took place in the context of two working groups dealing *inter alia* with issues related to aggregation and with the measurement of fishing capacity in the case of specific fisheries. The Consultation adopted the summary report of each working group, as presented in this document. The full proceedings of both working groups are also presented in Appendix H and J of the document. The outcome of the Consultation will form a basis for FAO to prepare technical guidelines for the measurement of fishing capacity in order to facilitate the implementation of the International Plan of Action.

Distribution:

All FAO Members

Participants at the session

Other interested nations and national and international Organizations

FAO Fisheries Department

Fishery Officers in FAO Regional Offices

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INTRODUCTION

1. The Technical Consultation on the Measurement of Fishing Capacity was held in Mexico City from 29 November to 3 December 1999 at the invitation of the Government of Mexico. Financial support to facilitate wide participation in the Technical Consultation was provided by the Governments of Japan and the United States of America.
2. The meeting was attended by 56 representatives from 30 Members of FAO and observers from four intergovernmental organizations. The list of participants is attached as Appendix B.

OPENING OF THE CONSULTATION

3. Mr Carlos Camacho Gaos, Under-Secretary for Fisheries, Mexico, welcomed the participants to Mexico City. He emphasized the importance of the subject and the need to take action. He expressed his concern that nearly 70 percent of world fisheries were fully or overexploited. In order that fisheries in the future also contribute to food security in the world and that fisheries be a provider of employment and social well-being in coastal areas, it was necessary to take action and establish a balance between fleet capacity and available resources. He pointed out that technical guidelines to measure fishing capacity were a very ambitious objective because of the many different factors which influenced the efficiency of fishing fleets and stressed that to reach this goal, all people involved in the process must speak a common language. He expressed the hope that this Consultation could be the starting point for global action to bring fishing capacity and resources into balance. He wished the Technical Consultation every success in this difficult task.
4. Mr Z.S. Karnicki, Director, Fishery Policy and Planning Division, FAO Fisheries Department, addressed the Consultation on behalf of the Director-General, Dr Jacques Diouf. He expressed his appreciation to the Government of Mexico for hosting this Consultation and providing excellent working facilities. He also thanked the Governments of Japan and the United States of America for their financial support. He pointed out that this last decade had been a decade of global action directing world fisheries to become more and more responsible. He noted that the International Plan of Action for the Management of Fishing Capacity adopted by the Twenty-third Session of the FAO Committee on Fisheries (COFI) in February 1999 called upon FAO to organize this Consultation with the aim of discussing in depth matters related to the measurement of fishing capacity. The outcome of the Consultation should form a basis for FAO to prepare technical guidelines for the measurement of fishing capacity in order to facilitate the implementation of the International Plan of Action.
5. Mr. Simoes Lopes Neto, FAO Representative in Mexico, also welcomed the delegates to Mexico, highlighting the excellent relationship between FAO and Mexico and wishing success to the meeting.
6. Ambassador Carmen Moreno, Under-Secretary for the United Nations, Africa and the Middle East, Mexico, opened the meeting.

ELECTION OF CHAIRPERSON

7. Mr Jeronimo Ramos Sáenz Pardo, Director General for Fisheries Management, Mexico, was unanimously elected Chairperson of the Consultation.

ADOPTION OF THE AGENDA

8. The Agenda adopted by the Consultation is attached as Appendix A. The documents which were before the Consultation are listed in Appendix C.

9. The Technical Secretary of the Consultation, Mr Dominique Gréboval, presented document FI:MFC/99/2 which set out the basis for the Consultation. He stressed the need to concentrate on the technical issues related to the measurement of fishing capacity required by countries in their assessment of fishing capacity and in the identification of fisheries requiring urgent action, with specific reference to paragraphs 13, 14 and 15 of the International Plan of Action for the Management of Fishing Capacity.

PAPERS PRESENTED DURING THE PLENARY SESSION

10. During the Plenary sessions, 26 papers divided among the following topics were presented:

- Objectives and Conceptual Considerations
- Country Experience
- Specific Measurement Methods (Peak to Peak and DEA)
- Specific Technical and Technological Considerations
- Aspects Related to Pelagic and Fluctuating Fisheries
- Aspects related to Tuna Fisheries
- Aspects related to Specific Fisheries

11. The list of papers submitted to the Consultation is given in Appendix D.

12. To facilitate the deliberations of the Working Groups, the Secretariat introduced a summary of major concepts and approaches which could be considered as a starting point for the discussions in the Working Groups. This summary is presented in Appendix E.

DELIBERATIONS OF WORKING GROUPS

13. After the presentation of the papers and following discussion, the Consultation divided into two Working Groups to discuss the measurement of fishing capacity in accordance with the terms of reference provided in document FI:MFC/99/3, which can be found in Appendix F.

SUMMARY REPORT OF WORKING GROUP 1

Introduction

14. Mr Niels Vestergaard (Denmark) was elected as the Chairperson and Mr Miguel Cisneros (Mexico) was elected as the Rapporteur for the Group.

15. It was agreed that the focus of the working group was on the issue of aggregating capacity measures to provide estimates at the fishery, national, regional and global levels. The group recognized that the fishery sector of any country was comprised of a combination of simple and complex (e.g. multi-species, multi-gear) fisheries, and that the focus of this group would be on the latter. The group accepted that they were required to produce simple yet useful measures.

Initial general discussion on aggregation and potential difficulties

16. The group recognized that the technical working group (La Jolla, 1998) defined capacity in terms of output, hence implying a species or production based measure. However, it was also recognized that information on overcapacity on a fleet segment basis was also required as these were the basic units of many management plans.

17. The group concluded that it would generally not be possible to determine a perfect measure of capacity due to problems of non-comparable and imperfect data. The group agreed that the design of any given measure of fishing capacity would depend on the nature of the data available.

Data dependent measurement of capacity

18. The hierarchy of data availability produced by Working Group 2 was considered and is attached as Appendix G. The first level (Level 0) involved the case where little or no quantitative data were available. In such a case, it was recommended that Participatory Research Methods (e.g. rapid appraisal, ethnographic surveys) be used to derive estimates of capacity and capacity utilization. The group recommended that all countries achieve at least Level 1 data for all fisheries as soon as possible.

19. For Level 1 data, the group concluded that Data Envelopment Analysis (DEA), Peak-to-Peak Analysis (PTP) and Stochastic Production Frontiers (SPF) could all be used. It was recommended that all three approaches be used and the results compared for consistency. The group recognized that any estimates of capacity using such data were crude, and recommended that the indicators be used with caution, and that the assumptions underlying their simplistic development be made explicit.

20. For Level 2 data, DEA could be used to estimate current capacity and potential capacity at the species level by aggregating across the fleet segments, and at the fleet level by aggregating across the species. The group noted that the measures could be aggregated to different levels, including across groups of species, domestic and international stocks, and at the global level. However, it was recognized that increasing the level of aggregation reduced the accuracy of the measure due to greater differences between fisheries at each level. Further, discards and unrecorded catch might result in a biased estimate of total capacity and of overcapacity. The group recognized these problems, and recommended that these indicators of capacity and overcapacity be used with caution, and that suitable caveats outlining their limitations be provided.

21. For Level 3 data, the group recommended that the same approaches be adopted as with Level 2 data. However, it was recognized that the greater detail allowed better estimates of the capacity and capacity utilization. The addition of prices allowed the assumption of perfect substitutability to be removed, and provided a means of deriving a more meaningful measure of aggregate capacity and target capacity (e.g. price indexed MSY). The group considered that since better information on fisheries management and/or better biological information were available, these should be used in the assessment of capacity. It was noted that resource management constraints could be directly incorporated into the assessment of capacity, and estimates of capacity could also be made with the removal of these constraints. The group concluded that analyses based on Level 3 data might be sufficient for the purposes of measuring capacity on a broad basis in the majority of cases.

22. For Level 4 data, DEA was again proposed as the most appropriate technique to assess capacity. It was noted that the addition of economic information allowed a more comprehensive assessment to be undertaken. For example, it permitted an analysis of the effects of changes in input and output prices and resources conditions on the efficient allocation of fishing capacity. Assessment of economic capacity and overcapacity could be undertaken through reference to a more appropriate target capacity level that incorporated social and economic information. However, the cost of collecting the additional data must be weighed against the added analytical benefits of collecting this information. The group concluded that if the data were available then they should be used and more comprehensive measures of capacity estimated. The group recognized that there were benefits in collecting such data for improving fisheries management in general, but there might not be sufficient benefits in collecting the data solely for the purpose of assessing capacity.

Other issues

23. Technical change was raised as an important issue. The group concluded that a number of approaches could be taken to quantify technical change, and the most appropriate approach depended on the characteristics of the fishery and the availability of data. It was suggested that experts in the field (e.g. fishers, gear technologists, etc.) be consulted to provide additional information to help identify technological change.

24. The group noted that the artisanal sector was often neglected in fisheries analyses despite its importance. For pure subsistence fisheries, methods to assess capacity and overcapacity were not apparent. The group recommended that the potential capacity of other small-scale fishing units be measured using the same techniques as for other commercial fisheries. However, it was recognized that data relating to this sector were often poor or non-existent. The group also noted that the definitions of artisanal, subsistence and small-scale commercial fisheries were unclear, and recommended that consistent definitions be provided by FAO.

25. The group recognized that both on-board and on-shore processing might impose limits on the quantity of catch that could be landed. Where these could be identified, they could be incorporated as a constraint in the DEA when measuring fleet capacity. Where overcapacity in processing facilities existed, the group recognized that the need to sustain throughput in the plants might induce pressure on the resource. The group also recognized that where fishing vessels and processors were vertically integrated, cross subsidization

may occur between the processing and harvesting activity. The group concluded that a different framework was required to integrate processing and harvesting capacity, but did not determine what this framework was.

26. The group considered the relative usefulness of technical-engineering approaches to capacity measurement compared with economic approaches. The group recognized that the economic approach provided potentially more reliable information as it explicitly determined the output level consistent with the behaviour of fishing units or operators. The group noted that the technological-engineering approach required less data, but recognized that the resultant measure should be viewed only as a rough approximation of the economic measure of capacity.

27. The group also discussed the influences of various ecological factors on catchability and agreed that such considerations could be incorporated into the analysis.

28. The group also considered aggregation of capacity in highly mobile fleets which interact with fleets in other areas and internationally. The group recognized that aggregation at the species and fleet level, domestic and international level and the global level was possible. However, the group noted that inaccuracies in the aggregate measure might increase the higher the level of aggregation due to incompatibility of effort units. The group also recognized that different management goals in different countries might need to be taken into account in assessing capacity.

29. The group recognized that both further research and training would be required. It was recommended that a simple training manual and user-friendly software be made available through FAO to researchers, managers and fishers.

30. The group recommended that further research be undertaken on the important issue of highly mobile fleets that interact with fleets in other areas and internationally. The group further recommended that additional research be undertaken on capacity measurement in those regions where artisanal fishing units were important components of the fisheries. The group also considered that further research be undertaken on methods based on catchability coefficients. The group also suggested that research be undertaken on: a) defining and measuring capacity for recreational fisheries; b) the impact on capacity of regulatory measures such as use of exclusion devices in trawl gear; c) use of capacity measures to improve fisheries management; d) capacity assessment in subsistence fisheries; and e) fish quality as a possible limiting factor to the measurement of capacity.

31. Proceedings of the deliberations of Working Group 1 are provided in Appendix H.

SUMMARY REPORT OF WORKING GROUP 2

Introduction

32. Dr. Pamela Mace (USA) was elected as Chairman and Mr John Casey (UK) was elected as Rapporteur of the Group.

Measuring fishing capacity, the case for relatively “simple” fisheries

Review of alternative methods, applicability and limitations

Types of capacity

33. The Group agreed with the basic measures of capacity as provided by the FAO Secretariat (See Appendix E). However, the Group considered that over-capacity (OC) as a basic concept should be replaced by relative capacity (RC) to take into account the fact that both over- and under-capacity were possible. The group also concluded that target catch level (TCL) would be a more widely applicable term to use in the context of relative capacity rather than Total Allowable Catch (TAC) since not all fisheries were managed by TAC. Target catch level was a more general term than TAC, includes TAC and could either be explicit or implied.

34. The group stressed the need to distinguish between overcapacity and overcapitalization. Overcapitalization included only the capital stock (a fixed input), whereas overcapacity was more all-encompassing in that it included 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.

35. The Group made extensive reference to the report of the FAO Technical Working Group on the Management of Fishing Capacity (Technical Working Group), held in La Jolla, USA, 15-18 April 1999 and concurred with the majority of the technical findings in the section on measurement and monitoring fishing capacity (paragraphs 63 to 88) and agreed with the definitions of fishing capacity and target capacity as follows:

Fishing capacity:

36. Fishing capacity is the maximum amount of fish over a period of time (year, season) that can be produced by a fishing fleet if fully utilized, given the biomass and age structure of the fish stock and the present state of the technology. Fishing capacity is the ability of a vessel or vessels to catch fish i.e.

$$Y_c = Y(E_c, S) \text{ where}$$

Y_c is the current yield/catch

E_c is the current effort

S is the stock size (biomass)

Target capacity:

37. Target fishing capacity is the maximum amount of fish over a period of time (year, season) that can be produced by a fishing fleet if fully utilized while satisfying fishery management objectives designed to ensure sustainable fisheries i.e.

$$Y_T = Y(E_T, S) \text{ where:}$$

Y_T is the target yield/catch

E_T is the target effort generated by a fully-utilized fleet

S is stock size (biomass)

The group considered that relative capacity should be defined as follows:

Relative capacity:

38. The general output based definition of relative fishing capacity is the ratio of current capacity to target capacity i.e.

$$\text{Relative capacity} = \frac{PC}{TCL} \text{ where:}$$

PC is the maximum potential catch

TCL is the target yield/catch

Overcapacity is not indicated if PC is less than TCL

Levels of data availability

39. With regard to the minimum data requirements for the measurement of fishing capacity, the Working Group identified and proposed a hierarchy of five levels of data availability. A detailed specification of the different levels is given in Appendix G.

40. The Working Group agreed that Level 1 should be identified as the minimum standard needed for the estimation of fishing capacity, Level 3 should be identified as the desired standard for the estimation of fishing capacity, and Level 4 should be identified as the long-term desired level for the estimation of fishing capacity, particularly for high volume and/or high impact fisheries.

41. The Working Group recommended that the priority for fisheries at Level 0 should be to initiate a data collection programme for at least Level 1 data as soon as possible.

42. In the meantime, qualitative information that may indicate potential excess capacity problems should be summarized; e.g. fishermen's views on trends in catch, or changes in sizes/species of fish in the catch; conflicts between sectors.

43. The Working Group identified the most important characteristics related to the calculation of capacity for the most important gear types used in small and large scale fisheries (see Appendix I).

44. The Working Group briefly discussed the measures of capacity that were possible at Level 1 (the minimum standard needed for estimation of fishing capacity) and Level 2 (which included qualitative or quantitative information on a much larger variety of factors). The benefits of moving from Level 2 to Level 3 were improved accuracy and precision of capacity measures, due to a greater diversity and quality of data, including biological data. The benefits of moving to Level 4 were dependent on the nature and complexity of specific fisheries.

45. The measures of capacity that were possible at Level 1 were highly aggregated estimates of capacity. These were likely to provide useful information when used to monitor capacity in fisheries. Both peak-to-peak and DEA were possible at Level 1. Peak-to-peak required a time series. DEA required a minimum of two data points. In both cases, the longer the time series, the more comprehensive and reliable the results.

46. The advantages of moving from Level 1 to Level 2 were, most fundamentally, a more disaggregated and detailed analysis. More disaggregated and detailed data gave a more accurate measure of capacity than did highly aggregated data. For example, the analysis could estimate capacity by stocks, fishery and/or gear type, and geographical area. The more detailed and disaggregated analysis could help form the basis for capacity management programmes.

47. A Level 2 analysis, when target catch levels (TCL) were available, could calculate the minimum number of vessels corresponding to the TCL, based on the harvesting technology.

48. The availability of fishing time or fishing activity data in a Level 2 analysis allowed estimation of capacity on a per period basis, which could then be combined with alternative season lengths and vessel numbers to address the capacity effects of different season lengths. The issue of latent capacity¹ could be addressed by estimating capacity for the existing vessels, and assigning these estimates of capacity to the vessels with no recorded landings, matching appropriate vessel and operating characteristics. However, due to the complexity of the issue of latent capacity, it needed to be addressed on a case by case basis.

49. A DEA analysis could incorporate environmental parameters (e.g., sea surface temperature, salinity, indices of primary productivity or convergence between different zones) and estimates of resource. A DEA analysis could also incorporate strategic behaviour of fishers, generalists versus specialists, inshore versus offshore, and other such distinctions either by separate analyses or by the use of binary or categorical variables or several other alternatives which were not discussed here.

50. Qualitative information could be extremely useful to assist in the proper formulation of capacity analyses and interpretation of the results.

51. Qualitative information might be useful for assessing the likely level of exploitation of a stock or group of stocks; e.g. qualitative information on trends in catches over time, and the average size or species composition of fish caught compared to what it could or should be. Those stocks most likely to be heavily over-exploited might then be identified as the highest priority for collection of the basic data.

52. Peak-to-peak and DEA needed to be widely applied to a variety of case studies so that these methods and their benefits and limitations could be more fully evaluated. An advantage of DEA was that it could be formulated to incorporate comprehensive data, including multiple vessel attributes, stock biomass, and environmental variables.

53. The Working Group recommended that FAO should obtain and distribute a manual on DEA, peak-to-peak and other relevant methods of estimating capacity; investigate possibilities for obtaining site licences for DEA software; and initiate and coordinate training programmes for the application of the various methods for estimating capacity.

¹ Latent capacity referred to vessels that were not currently active but were potentially active, and to vessels that were currently active at a low level.

Common indicative standard of long-term limit capacity which would allow for international comparisons

54. The Working Group noted that the definition of limit capacity proposed by the La Jolla Technical Working Group was the capacity commensurate with MSY. The group recognized that there were other long-run potential production limits used by some regional organizations and countries. The Working Group believed that this definition was useful to calculate the capacity level corresponding to MSY, but that this should be considered as an indicative upper bound on capacity, not as a limit in the sense implied by the precautionary approach which defined a limit as a boundary to be avoided with high probability. Thus, the Working Group preferred to think of MSY as a potential upper bound indicator to allow for international comparisons, but not as a critical upper bound beyond which the need to reduce capacity rapidly is critical. The group agreed that an upper bound on capacity might be derived with respect to an appropriate proxy for MSY.

Defining short-term and long-term target capacity

55. The difference between the two only matters if the resource was currently at levels far from optimal levels (either much higher or much lower than the level corresponding to the long-run target, with the latter situation being more common).

56. In the case of resources that were currently severely depleted, there existed the possibility that current capacity was far in excess of the capacity required to harvest optimally the resource (particularly if the stock was rebuilding), but that current capacity might be less excessive relative to the long-run rebuilt resource condition. Therefore, capacity management measures should also consider the long-run management objectives and projected resource conditions.

57. It should also be recognized that, in cases where the resource was currently at levels far from optimal levels, there were several difficulties in predicting the long-run target capacity. These difficulties related to potential changes in technology, market conditions, profitability and regime shifts. The severity of the problem increased with the length of the time horizon.

58. Life history (demographic) characteristics of the stocks concerned were also relevant in determining the urgency of the need to control capacity. In stocks that could rebuild quickly (e.g. many small pelagic stocks), rapid capacity reduction might be less imperative than in cases of stocks that were relatively much slower to respond to reductions in fishing pressure (e.g. many demersal stocks).

Correspondence between output (actual and target capacity) and fishing inputs

59. The definition of capacity derived at the La Jolla meeting was an output measure based on catch, and was accepted by the Working Group. However, the La Jolla Technical Working Group also recommended that there was a need to make the translation between output and input measures because fishery managers and others commonly equate fishing capacity with input-based measures such as the number and size or power of vessels. However it was essential to note that except under restrictive conditions, there was not a one-to-one correspondence between the two alternatives.

60. The Working Group recommended that more research needed to be done on the

question of linking output and input measures but that, in the meantime, the two could be treated as alternative measures of capacity and relative capacity.

Incorporation of complementary economic information in the measurement and evaluation of capacity

61. The La Jolla Technical Working Group recognized that the definition of capacity adopted by that group was primarily a technical definition, not an economic definition, and recommended that further work be conducted to develop an economic definition. The benefits of an economic definition were that it provided an explicit mechanism for incorporation of prices and costs and the firms' changes in the mixes of inputs and outputs when market conditions, biomass or environmental parameters changed. It provided an explicit mechanism for incorporation of pertinent social objectives, and directly addressed the incentives to invest or disinvest the capital stock when the firm or vessel exceeded or fell below the economic measure of capacity. The drawbacks were relevant economic data, especially costs, were usually lacking; it was not commonly applied by national governments in other industries, and was more difficult to estimate. Since cost and earning data for most fisheries were not available or collected on a continuous time basis, the measurement of capacity based on this definition should not be employed at present.

62. The Working Group also emphasized that the production capacity implicitly incorporated economic, biological and environmental factors in the sense that the data from a fishery reflect decisions related to costs, profits, and biological and environmental conditions. The Group also emphasized that the production capacity was a "best practice frontier", that is, it reflected the production capacity of the most efficient vessels for the time period analysed.

Measuring fishing capacity: The case for specific fisheries

Fisheries based on highly migratory resources

63. Highly migratory species were exploited by many countries and by a variety of gears. In addition several species were exploited in the same fisheries at the same time. However, the impact of such fisheries on the different stocks varied considerably. In addition the interactions between different gear types, coastal fisheries and offshore fisheries were further complicating factors.

64. There was also a need to foster greater cooperation between interested parties exploiting highly migratory resources, in particular through regional fisheries organizations.

Fisheries showing high fluctuations in stock abundance or availability

65. It should be recognized that most highly fluctuating resources were recruitment based and tended to have short life spans. In addition, recruitment and therefore stock size, tended to be highly correlated with environmental variables.

66. The Working Group recommended that capacity analysis should accommodate the situation where environmental conditions could be considered in at least two phases,

favourable and unfavourable, i.e. the existence of regime shifts should be recognized.

67. Special attention should be paid to the estimation of latent capacity, which could be extremely important in highly-fluctuating resources.

68. The behaviour of fishermen with respect to strategies and tactics employed to deal with highly fluctuating resources might be an important factor influencing the determination of capacity, for example, the level of mobility of fishermen and their ability to switch to alternative resources.

Small-scale fisheries

69. Small-scale fisheries were characterized by many simple small gear units and many participants which were widely dispersed. This posed significant and often complex problems in data acquisition. In addition the interaction between industrial fisheries and small-scale fisheries as well as biological interactions were complicating factors.

70. A further characteristic was that small-scale fisheries had a limited autonomy which was an intrinsic limitation on fishing capacity.

71. The group recognized that for the case of small-scale fisheries, data acquisition might be based on sampling; however not excluding the benefit of collecting information for the whole fishery. It was also noted that for the estimation of fisheries capacity in small-scale fisheries, the number of participants or gear units might be more important than the number of vessel units.

72. The group recommended estimation of the biomass of resources exploited by small-scale fisheries. Measures of capacity should take into account interactions between industrial fisheries and small-scale fisheries, as well as biological interactions.

Shared stock fisheries

73. The main characteristics of these fisheries were that stocks were fished by more than one country and therefore, data for measuring capacity should be collected in all countries involved in their exploitation.

74. The Working Group recommended that statistical methods and protocols used for data collection, analysis and reporting should be standardized to the extent possible so as to make information and measurements comparable.

Multi-species fisheries

75. It was recognized that multi-species fisheries presented several complexities. Several stocks were fished in a given area and several different fleet and gears might compete for these stocks. In addition, ecosystem considerations might needed to be taken into account; e.g. for small pelagics which formed the base of the food chain.

76. One of the important problems discussed in relation to multi-species fisheries was the difficulty of estimating capacity when several species were being fished with varying degrees of exploitation.

77. The Working Group recommended that the composition of the catch should be considered in assessing capacity since it might provide useful information on the state of the fishery over time. In addition, there was a need to consider incidental catch, discards and seasonal variations.

78. The Working Group also recommended that careful thought be given to the appropriate level of aggregation for species in multi-species fisheries.

79. Proceedings of the deliberations of Working Group 2 are provided in Appendix J.

Reporting on fishing capacity for the purpose of international comparison

80. After reviewing the report of the Working Groups 1 and 2, the Consultation recommended that particular attention should be given to how measures of capacity and over-capacity were reported for the purpose of international comparison.

ADOPTION OF THE REPORT

81. The Consultation recalled the provisions of the International Plan of Action for the Management of Fishing Capacity and agreed that the results of this Consultation should facilitate preliminary assessment of fishing capacity at national, regional and global levels and thus contribute to the implementation of the International Plan of Action.

82. The report of the Technical Consultation was adopted on 3 December 1999.

AGENDA AND TIMETABLE**Monday, 29 November 1999**

- Registration of participants
- Opening of the Technical Consultation
- Election of Chair
- Adoption of Agenda
- Introduction by the Technical Secretariat
- Presentation of selected technical papers
- Discussion of selected issues

Tuesday, 30 November 1999

- Plenary: Presentation of selected technical papers
- Plenary: Discussion of selected issues
- Plenary: Formation of two Working Groups
- Meetings of Working Groups

Wednesday, 1 December 1999

- Meetings of Working Groups

Thursday, 2 December 1999

- Meetings of Working Groups
- Working Groups: Drafting of technical report

Friday, 3 December 1999

- Working Groups: Drafting of technical report (continued)
- Plenary: discussion on proposals drafted by the Working Groups
- Plenary: Adoption of the report of the Technical Consultation
- Closing of the Technical Consultation

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LIST OF DOCUMENTS

- FI:MFC/99/1 Agenda, Timetable and Information Note
- FI:MFC/99/2 The measurement and monitoring of fishing capacity: introduction and major considerations
- FI:MFC/99/3 Provisional Indicative Terms of Reference: Working Groups 1 and 2
- FI:MFC/99/Inf.1 List of Documents
- FI:MFC/99/Inf.2 List of Participants
- FI:MFC/99/Inf.3 Information Note for Participants
- FI:MFC/99/Inf.4 Report of the Technical Working Group on the Management of Fishing Capacity (La Jolla, 15-18 April 1998)
- FI:MFC/99/Inf.5 Report of the Twenty-third Session of the Committee on Fisheries (Rome, Italy, 15-19 February 1999)
- FI:MFC/99/Inf.6 Statement of Competence of the European Community

LIST OF BACKGROUND DOCUMENTS

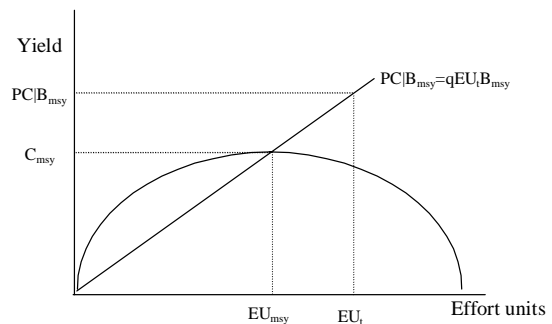
1. **Measuring Capacity and Capacity Utilization in Fisheries: The Case of the Danish Gillnet Fleet**
 By Niels Vestergaards - Institute of Environmental and Business Economics
 Dale Squire - U.S. National Marine Fisheries Service
 Jim Kirkley - Virginia Institute of Marine Sciences, USA
2. **The Measurement of Fishing Capacity in Chinese Fisheries and Related Control Practices**
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 Shanghai Fisheries University
3. **Tradable Property Rights and Overcapacity: The Case of the Fishery**
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 R. Quentin Grafton – University of Ottawa, Canada
 James Kirkley – Virginia Institute of Marine Sciences, USA
4. **Definition of Fishing Trip Types and Fleet Components in the Spanish Artisanal Fishery of the Gulf of Cádiz: A New Approach for the Study of Artisanal Fisheries**
 By Ignacio Sobrino, Luis Silva, Juan Gil
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5. **Monitoring, Measurement and Assessment of Fishing Capacity: the Malaysian Experience**
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6. **Monitoring, Measurement and Assessment of Fishing Capacity: the Nigerian Experience**
 By A.V. Amire
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7. **Fishing Capacity in Mauritania**
 By Chérif Ould Toueilib
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8. **Capacity and Offshore Fisheries Development: The Malaysian Purse Seine Fishery**
 By James Kirkley, Virginia Institute of Marine Science, USA
 Dale Squires, US National Marine Fisheries Service
 Mahammad Ferdous Alam, Bangladesh Agricultural University
 Ishak Haji Omar, Universiti Putra Malaysia
9. **Assessing Fishing Capacity of the Eastern Tropical Pacific Fleet of Skip Jack Tuna**
 By Ernesto A. Chavez
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10. **Simple Capacity Indicators for Peak to Peak and Data Envelopment Analyses of Fishing Capacity – A Preliminary Assessment**
By Timothy C.T. Hsu, Senior Statistics and Policy Advisor
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11. **State and Development of Fisheries in the Coastal Nile Delta Lakes of Egypt**
By Ali Ezzeldin Abdelghany
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12. **Fishing Capacity and Resource Management Objectives**
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University of British Columbia, Vancouver, Canada
13. **Fishing Capacity and EU Fleet Adjustments**
By Erik Lindebo
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14. **Technical Indicators of the Temporal Development of Fishing Power in the English Demersal Fisheries of the North Sea**
By C.M. O'Brien, J. Casey and B.D. Rackham
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15. **Critical Constraints to Regulate Fishing Capacity for Sustainable Harvests in Southeastern Brazil – Notes from the Brazilian Sardine Fishery Experience**
By Gasalla, M.A. & Tutui, S.L.S.
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16. **Distribution of Catch per Haul in Trawl and Purse Seine Fisheries – Possible Reduction of Fishing Capacity**
By Yoshihiro Inoue and Tatsuro Matsuoka
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17. **Some Important Factors in Controlling Fishing Capacity of Tuna Fisheries**
By Ziro Suzuki, Naozumi Miyabe, Miki Ogura, Hiroshi Shono
and Yuji Uozumi (National Research Institute of Far Seas Fisheries), Japan
18. **A Relationship between Fishing Effort and Fishing Capacity in Fluctuating Fish Stocks**
By Tatsu Kishida, National Research Institute of Far Seas Fisheries, and Tokio Wada, Fisheries Agency of Japan
19. **Assessing Capacity and Capacity Utilization in Fisheries when Data are Limited**
By James E. Kirkley, Rolf Fare, Shawna Grosskopf, Kenneth McConnell, Dale E. Squires, Ivar Strand
20. **Capacity and Capacity Utilization in Fishing Industries**
By James Kirkley, Virginia Institute of Marine Sciences and Dale Squires, U.S. National Marine Fisheries Service

21. **A Case Study of the Lane Snapper (*Lutjanus synagris*) in Batabano Gulf, Southwestern Region of Cuba**
By Servando Valle Gómez
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22. **Limiting the Growth of the Tuna Purse-Seine Fleet Fishing in the Eastern Pacific Ocean**
By James Joseph
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23. **Indian Experience on Assessment, Measurement and monitoring of Fishery Resources and Fishing Capacity**
By V.S. Somvanshi
Fishery Survey of India
24. **Fishing Capacity and Fisheries in Pakistan**
By Muhammad Hayat
Ministry of Food, Agriculture and Livestock, Pakistan
25. **Measurement and Management of Fleet Capacity in the European Union**
By: Michael Roitmann and Peter Hopkins
European Commission
26. **Medición de la Capacidad de Pesca de la Flota de Cerco Peruana**
By Jorge Zuzunaga
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BASIC MEASURES

Physical capacity	Production capacity
<p><i>Vessel units (VU):</i></p> <ul style="list-style-type: none"> measures of stock of capital e.g. boat number, GRT, kW, etc <p><i>“Effort” units (EU):</i></p> <ul style="list-style-type: none"> measure of flow of capital services e.g. sum(days fished*VU) <p><i>Potential effort units (PEU):</i></p> <ul style="list-style-type: none"> Effort if all capacity fully utilised e.g. sum(max days fished*VU) 	<p><i>Catch (C):</i></p> <p>Output measure based on effort and stock e.g. $C_t = q * EU_t * biomass_t$</p> <p><i>Potential Catch (PC):</i></p> <ul style="list-style-type: none"> Output if capacity fully utilised e.g. $PC_t = q * PEU_t * biomass_t$ e.g. $PC_t = \frac{C_t}{EU_t} PEU_t$
<p><i>Capacity utilization (CU_t):</i></p> <ul style="list-style-type: none"> $CU_t = EU_t / PEU_t$ $0 < CU_t < 1$ 	<p><i>Capacity utilization (CU_t):</i></p> <ul style="list-style-type: none"> $CU_t = C_t / PC_t$ $0 < CU_t < 1$
<p><i>Long term Overcapacity:</i></p> <ul style="list-style-type: none"> requires a reference point <p><i>Overcapacity at MSY (OC_{MSY}):</i></p> <ul style="list-style-type: none"> $OC_{MSY} = PEU_t / EU_{msy}$ <ul style="list-style-type: none"> requires estimate of EU_{msy} $OC_{MSY} = VU_t / VU_{msy}$ <ul style="list-style-type: none"> assumes full capacity utilization requires estimate of $VU_{msy} = \min$ (least cost?) fleet size required to harvest MSY 	<p><i>Overcapacity at MSY (OC_{MSY}):</i></p> <ul style="list-style-type: none"> $OC_{MSY} = (PC B_{msy}) / C_{msy}$ <ul style="list-style-type: none"> requires estimate of C_{msy} and potential catch given the biomass at MSY e.g. $PC B_{msy} = q * PEU_t * biomass_{msy}$ (See figure below)

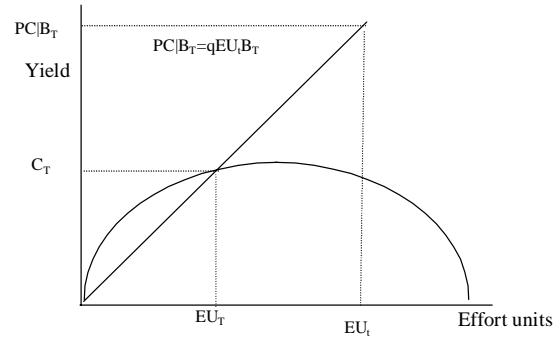


Overcapacity at Target Yield (OC_T)

- $OC_T = PEU_i / EU_T$
 - requires estimate of EU_T
- $OC_T = VU_i / VU_T$
 - assumes full capacity utilization
 - requires estimate of $VU_T = \min$ (least cost?) fleet size required to harvest target yield

Overcapacity at Target Yield (OC_T):

- $OC_T = (PC|B_T) / C_T$
 - requires estimate of C_T and potential catch given the biomass at target yield
 - e.g. $PC|B_T = q * PEU_i * biomass_T$ (See figure below)

*Short Term Overcapacity (OC_{ST})*

- $OC_{ST} = PEU_i / EU_{TAC}$
 - requires estimate of EU_{TAC}
- $OC_{ST} = VU_i / VU_{ST}$
 - assumes full capacity utilization
 - requires estimate of $VU_{ST} = \min$ (least cost?) fleet size required to harvest TAC

Short Term Overcapacity (OC_{ST})

- $OC_{ST} = (PC_i) / TAC$

TERMS OF REFERENCE OF WORKING GROUPS 1 AND 2

WORKING GROUP 1

Working Group 1 is invited to examine the matter of measuring fishing capacity, with due attention being given to the following considerations:

1) The need to adopt an aggregation system that accounts for fleet-stock interactions, fleet mobility and the requirements of managing fishing capacity -- noting that it may be required to measure capacity at various levels (regional, national and local) and that a common aggregation system will need to be adopted to estimate capacity at regional level and eventually at global level.

This might involve a review of the following aspects :

- Rationale for aggregating fisheries to account for mobility and capacity management requirements;
- Possible methods of aggregation at national level;
- Possible methods of aggregation at regional and global level;
- Research and data requirements;
- Applicability of common definition of capacity and overcapacity throughout the aggregation process and identification of likely difficulties.

2) The need to develop indicators that are particularly relevant to the case of broadly-defined fisheries, further accounting for the applicability of alternative indicators of capacity output and overcapacity under the likely conditions of such an approach (complex multifleets-multispecies aggregate fisheries);

This might involve a review of the following aspects:

- Determination of target and limit capacity in complex aggregate fisheries;
- Accounting for key characteristics of fleets such as: fleet heterogeneity, technological evolution over time and the case of small scale fisheries, when considered in an aggregated manner;
- Identification of simple indicators of capacity and overcapacity;
- Monitoring and measurement methods;
- Data and monitoring requirements;
- Ways of incorporating complementary economic information in the measurement and evaluation of capacity.

WORKING GROUP 2

Working Group 2 is invited to examine the matter of measuring fishing capacity, with due attention being given to the following considerations:

1) The need to develop simple indicators and methods to measure output capacity and estimate overcapacity in various fisheries -- noting that the evaluation of fishing capacity further requires the determination of target and limit capacity as well as the consideration of appropriate linkages between output and fishing inputs.

This might involve a review of the following aspects, in relation to the case of a relatively simple fishery:

- Review of alternative methods, applicability and limitations;
- Common indicative standard of long-term limit capacity which will allow for international comparison;
- Defining short-term and long-term target capacity;
- Correspondence between output (actual and target capacity) and fishing inputs;
- Ways of incorporating complementary economic information in the measurement and evaluation of capacity, in relation to both harvesting and post-harvest activities.
- Research and data requirements.

2) The need to adjust indicators and methods to the case of specific fisheries. It is proposed that the Working Group focus on the following cases, still retaining the premise of relatively simple fisheries (one or few stocks; one or few fleets) and focusing on the possible impact of the key characteristics of these fisheries on the measurement of fishing capacity and overcapacity :

- Shared-stocks fishery;
- Fishery based on highly-migratory resources, such as tuna;
- Fishery showing high fluctuations in stock abundance or availability;
- Any specific small-scale fishery.

For each case, this might involve a review of the following aspects:

- Impact on the determination of target and limit capacity;
- Need for adjustments in simple indicators and methods (or need to develop alternative approaches);
- Specific data and monitoring requirements.

LEVELS OF THE DATA AVAILABILITY

Level 0: Little or no quantitative data

Level 1: An estimate of total landings, plus

- ◆ In vessel-based fisheries: estimated total vessels
- ◆ In non-vessel-based fisheries: either number of participants or a measure of total gear units in use; e.g. total number of beach nets.

Level 1 is the minimum standard needed for estimation of fishing capacity.

Peak to peak and DEA analysis is possible with Level 1

Level 2: Level 1, plus

- ◆ An index of vessel size or power
- ◆ Gear type
- ◆ A rough index of trends in fishing success
- ◆ Rough measures of total time spent fishing and maximum potential time that could be spent fishing per year or per season, under normal operating procedures
- ◆ Basic relevant characteristics of fishing operations (e.g. seasonality, number and types of other fisheries in which vessels operate, use of fish-aggregating and fish-finding devices such as FADs, sonars, satellite tracking, other examples of changes in technology, autonomy of vessels, trans-shipment practices)

Level 3 : Level 2, plus

- ◆ Total catch (landings + discards), split by fleet sectors
- ◆ Basic biological information: e. g. resources distribution, catch by species, size structure, rough estimate of potential maximum sustainable yield
- ◆ Comprehensive primary vessel characteristics determining fishing power (e.g. GRT/GT or other volume measures, power (kW), fish hold capacity, vessel age; the importance of each of these varies with fishery type)
- ◆ Comprehensive information on gear type and dimensions
- ◆ Prices or revenues by major species
- ◆ Detailed effort and CPUE data, including time spent fishing

Level 3 is the desired standard for the estimation of fishing capacity

Level 4: Level 3, plus

- ◆ Detailed biological information on fish stocks: e.g. estimated biomass, fishing mortality rates, age/size structure, uncertainty in stock assessments
- ◆ Plus comprehensive data on other important features of fisheries that may be relevant to calculating capacity; for example, detailed information on fish-aggregating and fish-finding devices (e.g. sonars, FADs, satellite tracking), fish hold capacity, skipper and crew skill levels, fuel consumption, autonomy of vessels, processing capacity, costs and earnings surveys, prices, value of capital stock, employment, subsidies and economic incentives and fishing operations relative to fish distributions.

Level 4 is the long-term desired level for the estimation of fishing capacity, particularly for high volume or high impact fisheries.

PROCEEDINGS OF WORKING GROUP 1

Introduction

1. Mr Niels Vestergaard from Denmark was proposed and unanimously elected as the Chairperson for the Group. Mr Miguel Cisneros from Mexico was proposed and unanimously elected as the Rapporteur for the Group.
2. The terms of reference for the group were discussed and it was agreed that the focus of the working group was to examine the issue of aggregating capacity measures to provide estimates at the fishery, national, regional and (potentially) global levels. The group recognized that the fishery sector of any country is comprised of a combination of simple and complex (e.g. multi-species, multi-gear) fisheries, and that the focus of this group would be on the latter.
3. After accepting a proposal from the Chairperson, the group reconsidered the sheet outlining basic measures that had been presented at the end of the Plenary Session (see Appendix E). The group agreed to consider the basic measures presented as a guideline for the ensuing discussions.
4. A few points were made before the discussion began. Despite the fact that the group would have to deal in many cases with issues related to the complex nature of fisheries, the group agreed that they were required to produce simple yet useful measures. The group was also reminded that the goal was to develop a means to evaluate long-term overcapacity and that the group would need to consider methods to aggregate both within and over multi-species multi-gear fisheries.

Initial general discussion on aggregation and potential difficulties

5. Some of the participants expressed concern as to the feasibility of developing an aggregate measure of either physical capacity or production capacity due to the non-commensurability (i.e. inability to compare different measures) of the units (e.g. the problem of adding apples and oranges). Other participants asked the question of whether the group needed to develop species specific measures, or, alternatively, just define an aggregate level of capacity.
6. The group recognized that the previous technical working group (La Jolla, 1998) defined capacity in terms of output, hence implying a species or production based measure. However, it was also recognized that fisheries managers required information on overcapacity on a fleet segment basis as these are the basic units of many management plans. This implied that a physical capacity measure would also be required.
7. It was generally agreed that either approach was not meant to be chosen exclusively. Decision in this regard should rather be taken on a case-by-case basis. The group concluded that it would generally not be possible to determine a perfect measure of capacity. Instead, it was recognized that it was important to determine a practical measure and highlight the associated shortcomings.
8. During the course of the discussion, the issue was raised that measures of fishing capacity would, in many cases, need to take into consideration bycatch as well as discarded catch. The incorporation of bycatch and discards was considered relevant to the assessment of capacity. However, at what level bycatch and discards were incorporated was unclear. In particular, the issue of bycatch and discards of fish species that do not have a market value to the fishers was discussed. From an economic viewpoint, it was considered that discarding species that had no market value did not affect capacity, as these discards had no economic value. However, it was pointed out that in many cases, discards of juveniles (which might have no market value) have an impact on the biological resource, and might have longer term economic impacts in other fisheries.

9. There was some debate whether an aggregate measure of capacity was appropriate given the non-commensurability of units. The group considered the feasibility of aggregating measures of capacity in three hypothetical situations – one stock and two fleets; two stocks and one fleet; and two stocks and two fleets. The group agreed that, in the case of one species and two fleets, it was possible to aggregate potential catch across the fleets and derive a measure of capacity utilization. Similarly, in the case of two stocks and one fleet, it was accepted that it was possible to aggregate across the species to derive a measure of capacity for the fleet. However, a simple measure of aggregation was not readily apparent for the third case.

10. The group concluded that, given apparent difficulties in aggregation, measures needed to be provided at the species/stock level and fleet segment level prior to any attempts at aggregation. This might require input based physical measures for the fleet segments, and output based measures for the species/stocks. The group recognized that the two approaches would only be equivalent in certain restrictive circumstances (e.g. linear relationship between inputs and outputs). Some members of the group expressed reservations to the use of a strictly input based approach as it was inconsistent with the agreed definition of capacity. Data Envelopment Analysis (DEA) was proposed as a possible method that could be used to accommodate both species/stock level and fleet segment level estimates of capacity.

11. The group agreed that the design of any given measure of fishing capacity would depend on the nature of data available. The group also agreed that any measure needed to take into account the special characteristics of the fishery or fisheries being examined.

Data dependent measurement of capacity

12. The group considered the hierarchy of levels of data availability produced by Working Group 2 (Appendix G) with a view to determining the most appropriate method in each case. The second group determined 5 levels of data that were most likely to exist. These ranged from zero data (Level 0) to complete data on all aspects of the fishery (Level 4).

Level 0

13. The first level (Level 0) involved the case where no quantitative data of any kind were available. In such a case, it was recommended that Participatory Research Methods (e.g. rapid appraisal, ethnographic surveys) be used to: a) identify the fleet segments and the potential size of the fleet segments; b) collect estimates of current catch and other basic indicators; and c) collect estimates of potential catch. From these, estimates of capacity and capacity utilization could be derived.

14. The group recommended that in such a situation, the country should be encouraged to commence collection of basic data for the analysis of their fisheries as soon as possible. The above framework could also help determine the most appropriate data to collect. The group recommended that all countries achieve at least Level 1 data for all fisheries as soon as possible.

Level 1

15. Level 1 involved limited information on a national level on total vessels and total catch (not by species). In such a case, the data were already on an aggregate basis. It was assumed that time series of such data existed.

16. Some members of the group suggested that such limited data would be very rare, and in many cases estimates of catch and landings would be available at a more disaggregated level. For example, vessel numbers might be available by area and catch data might be available on a group basis (e.g. demersal species, pelagic species, etc).

17. The group concluded that DEA, Peak-to-Peak Analysis (PTP) and Stochastic Production Frontiers (SPF) could all be used even given such limited data. It was recommended that all three approaches be used and the results compared for consistency. The estimated capacity and capacity utilization would already be at an aggregate level. However, it would not be possible to produce estimates by fleet segment or by species (as this information does not exist).

18. The group recognized that the estimates of capacity and capacity utilization would be subject to a range of caveats. These included the assumptions that all species were perfect substitutes such that a tonne of one species was equivalent to a tonne of another species (i.e. it assumed both have equivalent prices). Also, the approach assumed homogeneity in inputs (i.e. all vessels were the same). As these assumptions were not realistic, the measure of capacity needed to be used with precaution.

19. The question of the validity of such an aggregation was raised given these assumptions. The group was reminded that such aggregation took place at many levels and in many industries. For example, the age structure of the catch was often ignored when defining the total weight of catch. In other industries, measures of productivity were combined to provide national indicators even though the outputs were different. Thus, while not an ideal approach, the measure provided a useful indicator of potential capacity given that the problems were recognized.

20. The question of long run overcapacity was investigated and two possible approaches were proposed. The first approach involved assuming that maximum sustainable yield (MSY) was equivalent to the average yield over the time series. The second approach was to develop a simple “yield-effort” relationship by regressing yield by the estimate of boat numbers and boat numbers squared (i.e. $Y=aV-bV^2$). From the resultant equation, an estimate of the maximum yield (assumed to be equivalent to MSY) could be derived. In both cases, the group recognized that the estimates were crude, but provided an indicator of target capacity and allowed estimates of potential long run overcapacity. Again, the group recommended that the indicators were to be used with caution and with consideration to their simplistic underlying assumptions.

Level 2

21. Level 2 data involved, in addition to the data in Level 1, estimates of catch by fleet segment (denoted by gear type) and species, as well as more information on the characteristics of the vessels (e.g. size and/or engine power). These data allowed estimates of capacity by fleet segment and by species.

22. The group considered the data as a matrix (see Figure 1), where interactions between the species and the fleet segments could be identified. In such a situation, total catch by species and total catch of each fleet segment could be estimated, as well as total fishery catch. Aggregation of catch over the fleet segment and for the fishery as a whole required an assumption of perfect substitutability between species.

Figure 1. Data matrix

Species	Fleet segment			Total
	1	2	3	
A	X		X	Catch _A
B	X	X		Catch _B
C			X	Catch _B
		X		
Total	Catch ₁	Catch ₂	Catch ₃	Total Catch

23. DEA and PTP were again proposed as potential methods to estimate current capacity and capacity utilization given such information. PTP could only be used to derive an output based measure of capacity, so did not provide information on capacity at the fleet segment level.

24. DEA could be used to estimate capacity for each point of interaction in the matrix. From these, measures of capacity at the species level could be derived by aggregating across the matrix, while measures of capacity at the fleet level could be made by aggregating down the matrix. The resultant measure were therefore consistent. In addition, a measure of total fishery capacity could be derived by aggregating across all fleets or all species. However, it was recognized that the aggregation of the

capacity measures at the species, fleet segment and total fishery level were imprecise as they again involved the assumption of perfect substitutability between species. The group recognized that different levels of aggregation might be undertaken (e.g. group similar fleet segments or similar species rather than all fleet segments and all species), and that the level of inaccuracy increased with the level of aggregation.

25. Long term measures of overcapacity were discussed. It was noted that long term measures could be estimated using DEA provided that suitable reference levels of yield and stock could be provided. Concerns were raised about the ability to accurately estimate MSY (or other target capacities) given the limited data and given the multispecies nature of the fisheries. As a result, the group concluded that any estimated long run measure of overcapacity needed to be used with caution.

26. The potential problem of discards and unrecorded catch was again raised. In some cases, some species might not be recorded by some fleet segments. The example was given of Mauritanian shrimp vessels which did not record the bycatch of hake. However, hake was the target species for other fleet segments. Total catch of hake was therefore underestimated, resulting in a biased estimate of total capacity and overcapacity. The group recognized that the direction of bias might be positive or negative.

27. The group recognized these problems, and recommended that the estimated measures of capacity and overcapacity be treated only as indicators rather than precise measures. As a result, these indicators needed to be used with caution, and suitable caveats outlining their limitations were also required to be provided.

Level 3

28. Level 3 data incorporated all data in Level 2, with the addition of measures of “effort” (e.g. days fished), more details on vessel characteristics and information on landings during the year (providing information on seasonality). Level 3 data also included prices.

29. The group recommended that the same approaches be adopted as with Level 2 data. However, it was recognized that the greater detail provided better estimates of the capacity and capacity utilization. For example, the information on “effort” allowed the estimation of capacity and potential capacity on the basis of full input utilization (e.g. full use of days fished). Further, the addition of prices allowed the assumption of perfect substitutability to be removed, and provided a means of deriving a weighted index of capacity. As a result, a more meaningful measure of aggregate capacity and target capacity could be derived.

30. The group considered that information on fisheries management would also most likely be available and that this information should be used in the assessment of capacity. It was recognized that fisheries management might impose constraints on capacity and efficiency, and that potential capacity needed to be assessed in the absence of these additional constraints. For example, if a days-at-sea restriction was in place and this limited the capacity of the fishing units, potential capacity needed to be assessed with this constraint removed.

31. It was noted that DEA could directly incorporate resource management constraints in the assessment of capacity, and could also estimate capacity with the removal of these constraints. However, it was recognized that removal of these constraints might result in unrealistic input usage, and that these results might need to be adjusted in line with more reasonable input usage. This latter usage could be estimated by examining pre-regulation activity, through consultation with industry or gear technologists, or through controlled at-sea experiments (the latter being fairly expensive).

32. Long run measures of overcapacity were not extensively discussed as the approach was regarded to be the same as for Level 2 data and subject to similar problems. However, the improved data were likely to lead to better estimates of the target measure of capacity. For example, target capacity can be defined as a price indexed MSY.

33. The group concluded that analyses based on Level 3 data might be sufficient for the purposes of measuring capacity on a broad basis in the majority of cases.

Level 4

34. Level 4 data included the data in Level 3, as well as more detailed biological data and more detailed economic data (including information on costs and earnings of the fishing units).

35. DEA was again proposed as the most appropriate technique to assess capacity. However, the addition of economic information allowed a more comprehensive assessment to be undertaken. These included the potential for a profit maximisation approach or a cost minimization approach to be adopted. These approaches allowed for fisher behaviour to be incorporated into the analysis, which allowed the issues of allocative efficiency to also be addressed. For example, the effects of changes in input and output prices and resource conditions on the efficient allocation of fishing capacity could be assessed. Hence, assessment of economic capacity and overcapacity could be undertaken through reference to a more appropriate target capacity level that incorporated social and economic information. This provided managers with additional information on the potential economic benefits of adjusting capacity in the various fleet segments.

36. While the potential advantages in terms of improved estimates of capacity and overcapacity were recognized by the group, a number of members questioned whether the additional costs of collecting the additional data exceeded the benefits. The group concluded that if the data were available then they should be used and more comprehensive measures of capacity estimated. The group recognized that there were benefits in collecting such data for improving fisheries management in general. The group concluded that individual countries needed to weigh the additional costs of collecting the additional data against the added analytical benefits that this information would confer.

Other issues

37. The group addressed a number of other issues relating to the assessment of capacity and overcapacity that might be relevant in refining the analyses.

Technological development

38. The effects of changes in technology over time on the assessment of capacity were considered, along with how these changes could be incorporated into the measurement of capacity utilization and overcapacity.

39. It was noted that DEA and PTP could provide estimates of technological change over time. However, it was felt by the group that other factors might also be mistaken for technological change. These included environmental changes (e.g. El Niño), changes in market conditions or improvements in skipper and crew skill and knowledge.

40. It was suggested that experts in the field (e.g. fishers, gear technologists, etc) be consulted to provide additional information to help identify technological change. A suggestion was also made that changes in catchability coefficients could also provide information on technological change. However, these might be also subject to the same problems as the DEA or PTP. The group noted that a number of approaches could be used, and the most appropriate approach depended on the characteristics of the fishery and the availability of data. The group concluded that further research was required to assess the effects of technological change on the measurement of capacity.

Artisanal fleets

41. The group noted that the artisanal sector was often not adequately incorporated into fisheries management plans and measures, despite its importance.

42. The group considered three types of artisanal fleets: pure subsistence fisheries, small-scale part time fishers, and small-scale full time commercial fishers. It was recognized that the capital used by these fishers might not involve a vessel, but might take the form of fishing gear or even labour. It was recommended that the most appropriate inputs be used to define fishing units in any analyses.

43. For pure subsistence fisheries, a method for assessing capacity and overcapacity was not apparent. This sector caught only what was needed and while technologically they could catch more, by definition they did not catch more than required for food purposes. As a result, it was not clear that they behaved in an optimizing manner (e.g. maximize outputs given their fixed inputs or minimize their costs to achieve their desired catch) and hence the standard methods might not be appropriate. Similar problems were likely to exist when attempting to assess capacity in recreational fisheries. The group suggested that further research would be required to address this issue for both recreational and subsistence fisheries.

44. Small-scale part time fishing units in many countries were also associated with part time farming (or other activities). Hence, when conditions were not favourable in the other activity, fishing activity could increase. The group recommended that the potential capacity of this group of fishers be considered in the same manner as full time fishing units.

45. The group recommended that small-scale commercial (i.e. full time) fishing units be assessed in the same manner (i.e. using the same techniques) as their larger counterparts in the measurement of fishing capacity. However, it was recognized that data relating to this sector were often poor or non-existent. As a result, the approach might be limited to those used in the case of Level 0 or Level 1 categories of data.

46. It was recognized that many artisanal fleets interacted with larger commercial or industrial fleets. In such a case, the group concluded that the combined capacity of the artisanal fleet and industrial fleet needed to be considered. This might also extend to subsistence fishing units when they interacted with industrial fleets, as this would affect the potential capacity of the larger fishing units.

47. The group also noted that there were no clear definitions of artisanal, subsistence and small-scale commercial fisheries. The group recommended that a consistent definition of all these terms be developed for use in the assessment of capacity.

Processing

48. The group considered the influence of processing on the measurement of capacity and potential capacity. The group considered both on-shore and on-board processing.

49. The group recognized that where on-shore processing had surplus capacity, the need to maintain throughput in the plants might increase the demand for product from the fishing fleet and provide additional incentives to increase harvesting levels. This had implications for the measurement of capacity.

50. In some cases, on-shore processing might impose limits on the quantity of catch that could be utilized upon landing. In such cases, the processing acted as a constraint to the total capacity of the fleet. Where this could be identified it could be incorporated as a constraint in the DEA when measuring fleet capacity.

51. The group also recognized that where fishing vessels and processors were vertically integrated, production decisions were made on the basis of the value of the final product. As a result, cross subsidization might occur between the processing activity and the harvesting activity in order to maximize overall profits. Consequently, fleet activity might not be consistent with the assumptions underlying the main techniques used to assess capacity. The group concluded that a different framework was required to integrate processing and harvesting capacity, but did not determine what this framework was.

52. The group noted that on-board processing could act as a constraint on the production of the vessel. This could be incorporated into the DEA analysis directly as a technical constraint.

Distinction between technical and economic measures

53. There remained some confusion as to the differences between the technological-engineering approaches required for the analyses with Level 3 data and the economic approach that could be developed with Level 4 data. The group requested further discussion on this. A simple economic model

was presented to illustrate how a given industry might operate in an economically efficient manner, and how this might affect the measurement of capacity.

54. The group considered two measures of capacity: (1) a technological-engineering definition, and (2) an economic measure. Both measures might be expressed in terms of either an input or an output orientation, but they did differ in how they were calculated. Input oriented approaches examined the minimum inputs to achieve a given level of output. Output oriented approaches aimed to maximize the potential output given a fixed level of inputs.

55. It was recognized by the group that the measurement of capacity from a technological-engineering perspective had only negligible economic content. That is, it was strictly the output level corresponding to the maximum potential output that a vessel or operating unit could produce, regardless of input and output prices. Economic behaviour, other than maximization of outputs, was not directly incorporated into the technological-engineering measure of capacity. Formally, the technological-engineering measure was the maximum possible output that could be produced per unit of time with existing plant (e.g., the vessel) and equipment (e.g., a trawl net) provided the availability of the variable factors of production (e.g., labour and fuel) were not restricted.

56. The group recognized that, empirically, the technology-engineering definition implicitly reflected economic responses (i.e. landings were actually determined by fishers in accordance with underlying behavioural objectives). The PTP and DEA approaches were two methods that might be used to calculate the technological-engineering measure of capacity in fisheries. In the absence of appropriate data, an ethnographic field survey might be used to obtain information appropriate for estimating the technological-engineering measure of capacity.

57. The group considered the information required to estimate capacity from an engineering approach. It was noted that estimating the technological-engineering measure of capacity using the PTP or DEA approach required, at a minimum, information on landings and number of fishing units (e.g., vessels or operating units). Improvements in the precision of the estimates, however, were possible with additional information (e.g., data reflecting the scope, size, and type of fishery and dimensions on the various capital stocks). The group concluded that the technological-engineering measure should be viewed only as a rough approximation of the economic measure of capacity.

58. The group considered also the economic concept of capacity. This was noted as the output level (nominal catch or landings) determined in accordance with a given behavioural objective (e.g., profit maximisation, cost minimisation, or revenue maximization), and a fishing unit operating under customary and normal operating conditions. The economic measure was distinguished from the technological-engineering measure in that it explicitly determined the output level consistent with the behaviour of fishing units or operators.

59. The group recognized that the economic measure of capacity, provided adequate data on costs and earnings were available, might be calculated in several ways. First, a very crude measure might be constructed by determining the output level corresponding to minimum average cost; a sufficiently long-time series of costs and landings data, however, would be required for this calculation. A second approach considered previously by the group was that of DEA. Using DEA and having information on input and output prices, an economic measure consistent with cost minimization, revenue maximization, or profit maximization might be calculated. Third, the economic measure might be calculated by statistically estimating models of economic behaviour, and subsequently, determining the output level consistent with achieving the objective of the behavioural model. The group recognized that, in the case of multiple outputs (e.g., two or more species) and multiple fixed factors (e.g., winches, trawls, and on-board processing facilities), it might not be possible to adequately estimate capacity without imposing very restrictive conditions on the technical and economic interactions.

60. The group noted that a key advantage of using the more comprehensive economic approach was that the potential economic waste in fisheries could be readily identified. The group considered the usefulness of explicitly incorporating labour, social and sociological information into this framework, especially in the case of small scale fisheries. As a result, the approach provided information on the most

appropriate use of the resource from the viewpoint of society as a whole.

61. The group also considered the usefulness of the different capacity evaluation techniques when ecological factors needed to be considered. It was suggested that the economic models could and did take into account stock dynamics, as for example, costs of harvest decrease as stock increased. It was also noted that economic models could accommodate social aspects such as labour. It was noted that studies based on catchability might also explicitly include complex ecological interactions. As a result of the discussions, the group agreed that such considerations could be incorporated into the analysis.

Mobility and global aggregation

62. The group also considered aggregation of capacity in highly mobile fleets which interact with fleets in other areas and internationally. Once capacity utilization indicators had been estimated by the fleet and species for each country, the group felt that this information could be conceivably aggregated by species/stock and by fleet type at a global level. This assumed that capacity was fully and linearly additive. The group recognized that this was a rather rough approximation, which would likely overestimate total capacity. The group noted that inaccuracies in the aggregate measure might increase as the level of aggregation increased due to incompatibility of effort units.

63. Despite the problems associated with aggregation, the group felt that the aggregated information would provide a general indication of the order of magnitude of capacity utilization in the fisheries sector. The group felt that the calculation of an indicator of total capacity utilization for all fleet segments harvesting a given species or stock would provide a useful, albeit approximate, indication of the magnitude of balance or imbalance that existed between fishing capacity and the resource. The group agreed that aggregation would need to be done along logical units, such as discrete biological stocks.

64. At the national level, the group felt that such aggregation would allow fisheries managers to determine the level of inefficiency in the allocation of fishing effort, and to consider possible strategies to redistribute, constrain or retire fishing capacity to ensure a more appropriate balance with the resource.

65. At the international level, the group felt that the aggregation could be undertaken between those countries harvesting shared international, transboundary, highly migratory and straddling fish stocks. This was with a view to informing discussion in the appropriate regional fisheries management organization (RFMO) about the potential risks that the combined national fleet capacity prosecuting these shared fish resources might present for the short and long term conservation of the stocks. In this context, RFMO officials would have an opportunity to consider the implications of the mobility of certain countries and/or fleet segments across species and/or national lines and to discuss any policies or measures that might eventually be considered to manage such fleet mobility.

66. The group, however, was unclear to what extent aggregation could take place when the fleets were highly mobile due to the problem of allocation of capacity to different areas. A methodology was not apparent as to how this could be achieved, and it was suggested that this is an important area for future research. As a first step, it was suggested that the possibility of constructing a mobility index should be investigated.

67. The group also recognized that different management goals in different countries might need to be taken into account in assessing capacity. However, for international comparison, a common reference point was required.

Research and Training

68. The group recognized that both further research and training would be required before many countries could undertake any assessments of capacity. It was recommended that a simple training manual and user-friendly software be made available through the FAO to researchers, managers and fishers. The training manual was to outline how DEA could be used to assess capacity and capacity utilization in the fishery context, and how vessel or trip data were to be incorporated into the analysis.

69. The group recommended that further research be undertaken on the issue of highly mobile fleets that interacted with fleets in other areas and internationally.

70. The group further recommended that additional research be undertaken on capacity measurement in those regions where artisanal fishing units were important components of the fisheries. In particular, the group recommended additional research into capacity assessment in subsistence fisheries.

71. The group also considered that further research be undertaken on methods based on catchability coefficients.

72. The group also suggested that research be undertaken on a number of other research topics. These include:

- a) defining and measuring capacity for recreational fisheries;
- b) the impact on capacity of regulatory measures such as use of exclusion devices in trawl gear;
- c) use of capacity measures to improve fisheries management; and
- d) fish quality as a possible limiting factor to the measurement of capacity.

International cooperation

73. The group stressed the importance of international cooperation in the assessment of fishing capacity. In the course of the meeting, some participants stressed the need for international support to be provided to developing countries for carrying out systematic assessment of their capacity, and more generally, to help with the implementation of the Plan of Action.

MAJOR CAPACITY CHARACTERISTICS BY GEAR TYPE

- All: Number of vessels, licences, participants, or gear units (whichever is relevant); length of trip; actual number of trips per year or season; potential number of trips per year or season; total catch including discards; level of mechanization
- Beach nets: All, plus total length of nets
- Handline: All, plus number of lines employed
- Set nets: All, plus total length of net, average set time
- Traps: All, plus number of traps, average soak time
- Diving: All
- Purse seine: All, plus time searching, use of fish aggregating or fish-finding aids such as FADs, aeroplanes and sonar, average sets per trip, vessel GRT or GT or other volumetric measure, kW, fish hold capacity
- Longline: All, plus average hooks per set, average sets per trip, average soak time, use of fish-finding aids, vessel GRT or GT or other volumetric measure, fish hold capacity
- Gill net: All, plus type of net, total length and depth of net, mesh size, average set time, average sets per trip, use of fish-finding aids, vessel GRT or GT or other volumetric measure, fish hold capacity
- Trawl/Dredge: All, plus gear dimensions, mesh size, tow time, average tows per trip, use of fish-finding aids, vessel GRT or GT or other volumetric measure, kW, fish hold capacity

PROCEEDINGS OF WORKING GROUP 2

Introduction

1. The meeting of Working Group 2 on the measurement of fishing capacity was held in Mexico City, Mexico from 30 November to 3 December 1999.

Opening of the meeting.

2. Dr Karnicki, from the FAO Secretariat opened the meeting and welcomed participants.
3. Dr Pamela Mace (USA) was elected Chair of the Working Group and Dr John Casey (UK) was appointed Rapporteur.

Terms of reference:

4. Working Group 2 was invited to examine the matter of measuring fishing capacity, with due attention being given to the following considerations:
 - i) The need to develop simple indicators and methods to measure output capacity and estimate overcapacity in various fisheries -- noting that the evaluation of fishing capacity further requires the determination of target and limit capacity as well as the consideration of appropriate linkages between output and fishing inputs.
5. This might involve a review of the following aspects, in relation to the case of a relatively simple fishery:
 - Review of alternative methods, applicability and limitations;
 - Common indicative standard of long-term limit capacity which would allow for international comparison;
 - Defining short-term and long-term target capacity;
 - Correspondence between output (actual and target capacity) and fishing inputs;
 - Ways of incorporating complementary economic information in the measurement and evaluation of capacity, in relation to both harvesting and post-harvest activities;
 - Research and data requirements.
 - ii) The need to adjust indicators and methods to the case of specific fisheries. It was proposed that the Working Group focus on the following cases, still retaining the premise of relatively simple fisheries (one or few stocks; one or few fleets) and focusing on the possible impact of the key characteristics of these fisheries on the measurement of fishing capacity and overcapacity :
 - Shared-stocks fishery;
 - Fishery based on highly-migratory resources, such as tuna;
 - Fishery showing high fluctuations in stock abundance or availability;
 - Any specific small-scale fishery.
6. For each case, this might involve a review of the following aspects:
 - Impact on the determination of target and limit capacity;

- Need for adjustments in simple indicators and methods (or need to develop alternative approaches);
- Specific data and monitoring requirements.

7. The Chair outlined the provisional Agenda, which was accepted by the Group. The Working Group agreed that the way to proceed would be to address each of the suggested areas for review individually, at the same time keeping in mind the overall objectives of the technical consultation, which was the measurement of fishing capacity.

8. The Group discussed whether the case of a simple fishery should include multi-species fisheries and concluded that this was the case, but that it should refer only to simple multi-species cases. It was pointed out that consideration of shrimp fisheries was an important factor, but that capacity measurements for aquaculture were beyond the scope of the present Working Group.

Simple indicators and methods to measure output capacity and estimate overcapacity: the case for "simple" fisheries

Review of alternative methods, applicability and limitations

Types of capacity

9. The Working Group referred to a schematic provided by the FAO Secretariat on the basic concepts of physical and production measures of capacity (Table 1), noting that capacity could be measured either as an input or an output measure. As a result of a general discussion on capacity, the group considered that the term over-capacity (OC) as a basic concept should be replaced by relative capacity (RC) to reflect the fact that in some fisheries there might be under-capacity. The group also concluded that total catch level (TCL) would be a more appropriate term to use in the context of relative capacity rather than Total allowable catch (TAC) since not all fisheries were managed by TAC. The Group was of the opinion that Target catch level was a more general term than TAC, included TAC and could either be explicit or implied.

10. Recognizing that physical measures such as numbers of vessels of fishing effort were input measures of capacity, whereas production measures such as catch and potential catch were output measures, the Working Group discussed the relationship between the two types of capacity measures. With reference to the definitions of capacity proposed in the Report of the Technical Working Group on the Measurement on Fishing Capacity held in La Jolla, in April 1999 (Technical Working Group), the Group agreed that a definition of capacity as an output measure was appropriate but agreed that there was a need to make the translation between input and output measures, since fishery managers and others commonly equated fishing capacity with input measures such as the number and size or power of vessels.

11. With reference to the report of the Technical Working Group, the group concurred with the majority of the technical findings of that meeting and agreed with the definitions of fishing capacity and target capacity. These were defined as follows:

Fishing capacity:

12. Fishing capacity is the maximum amount of fish over a period of time (year, season) that can be produced by a fishing fleet if fully utilised, given the biomass and age structure of the fish stock and the present state of the technology. Fishing capacity is the ability of a vessel or vessels to catch fish i.e.

$$Y_c = Y(E_c, S) \text{ where}$$

Y_c is the current yield/catch

E_c is the current effort

S is the stock size (biomass)

Target capacity:

13. Target fishing capacity is the maximum amount of fish over a period of time (year, season) that can be fully utilized while satisfying fishery management objectives designed to ensure sustainable fisheries i.e.

$$Y_T = Y(E_T, S) \text{ where:}$$

Y_T is the target yield/catch

E_T is the target effort generated by a fully-utilised fleet

S is stock size (biomass)

14. After discussion the group agreed that a general term for both overcapacity and/or undercapacity should be defined and agreed on the term **relative capacity** which was defined as follows:

Relative capacity:

15. The general output based definition of Relative fishing capacity is the ratio of current capacity to target capacity i.e.

$$\text{Relative capacity} = \frac{PC}{TCL} \text{ where:}$$

PC is the maximum potential catch

TCL is the target yield or catch

Overcapacity is not indicated if PC is less than TCL

16. The group also discussed a common terminology for referring to capacity noting that input measures of capacity could be referred to as physical measures whereas output measures could be referred to as production measures. The group considered that although the terms could be interchangeable, the terms physical and production capacity should be the normal terminology used.

Overcapacity and overcapitalization

17. Noting that the terms overcapacity and overcapitalization were currently used rather loosely, the group stressed the need to distinguish between the two terms. It was agreed that overcapitalization included only the capital stock (a fixed input), whereas overcapacity was more all-encompassing in that it included 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.

Experience in measuring capacity

18. Participants were asked for their experiences in measuring both physical and production capacity. The Working Group was informed that data collected by the European Union (EU) was collected on an individual vessel basis with Gross Tonnage (GT) and engine power as the main capacity measures. Individual vessels were assigned a unique vessel ID and the following data for individual vessels must be reported to the European Commission (EC) by EU Member States: vessel name, registration number, country of registration, port of registration, date of entry into service, date of construction, international radio call-sign, overall length (m), length between perpendiculars (m), main engine power, auxiliary engine power, gears used.

19. In addition, each vessel was allocated to a fleet segment, which comprised a relatively homogeneous group of vessels that exploited specific stocks in specific fishing areas. It was the responsibility of member States to define its fleet segmentation.

20. No other national experiences on the measurement of capacity were discussed.

Data required for capacity measurement

21. The Working Group referred to the Report of the FAO Technical Working Group on the Management of Fishing Capacity (Technical Working Group), held in La Jolla, USA, 15-18 April 1999, noting that there were several suggestions included in that report regarding data requirements that were appropriate to this Working Group. However the Group agreed that the two levels of data proposed by the Technical Working Group were not sufficient to cover all types of fisheries.

22. After considerable discussion, the Working Group identified and proposed a hierarchy of five separate levels of data required depending on the type of fisheries concerned. These were designed to allow some measure of capacity for all types of fisheries, and each level provided additional scope for improving the estimate of fishing capacity. A detailed description of the different levels of data and information is given in Appendix G, together with the proposed actions associated with the different levels.

23. The discussion in relation to level zero, for which little or no quantitative data exist raised numerous concerns. The Group was of the opinion that even if no quantitative information existed, qualitative indicators, for example from opinion surveys, might give an indication whether particular resources were stable, increasing or declining. One potential useful indicator might be in the situation where a resource was shared by a number of fishery sectors, which might result in conflict between such sectors. In principle, if no such conflict existed, this might be an indication that there was no over-capacity. The group recognized that indicators such as these were of limited use in assessing capacity and recommended that appropriate measures should be invoked in such cases to at least obtain the information specified for Level 1 as quickly as possible.

24. The group agreed the following:

- Level 1 should be identified as the minimum standard needed for the estimation of fishing capacity.
- Level 3 should be identified as the desired standard for the estimation of fishing capacity.
- Level 4 should be identified as the long-term desired level for the estimation of fishing capacity, particularly for high volume or high impact fisheries.
- The Working Group recommended that the priority for fisheries at Level 0 should be to begin a data collection programme for at least Level 1 data as soon as possible.
- The group agreed that data collection programmes should ultimately move beyond Level 1, as soon as possible.

25. The Working Group identified the most important characteristics related to the calculation of capacity for the most important gear types used in small and large-scale fisheries and the findings are summarized in Annex Y.

Benefits of collecting data at different levels and methods available

26. The Working Group briefly discussed the measures of capacity that were possible at Level 1 (the minimum standard needed for estimation of fishing capacity) and Level 2 (which included qualitative or quantitative information on a much larger variety of factors). The benefits of moving from Level 2 to Level 3 were improved accuracy and precision of capacity measures, due to a greater diversity and quality of data, including biological data. The benefits of moving to Level 4 were dependent on the nature and complexity of specific fisheries.

27. The measures of capacity that were possible at Level 1 were highly aggregated estimates of capacity. These were likely to provide useful information when used to monitor capacity in fisheries. Both peak-to-peak and DEA were possible at Level 1. Peak-to-peak required a time series. DEA required a minimum of two data points. In both cases, the longer the time series, the more comprehensive and reliable the results.

28. The Working Group agreed that the measures of capacity that were possible at Level 1 are highly

aggregated estimates of capacity, which were likely to provide useful information when used to monitor capacity in fisheries. Both peak-to-peak and DEA were possible at Level 1. Peak-to-peak required a time series. DEA required a minimum of two data points. In both cases, the longer the time series, the more comprehensive and reliable the results.

29. The advantages of moving from Level 1 to Level 2 were, most fundamentally, a more disaggregated and detailed analysis. More disaggregated and detailed data gave a more accurate measure of capacity than highly aggregated data. For example, the analysis could estimate capacity by stocks, fishery and/or gear type, and geographical area. The more detailed and disaggregated analysis could help form the basis for capacity management programmes. The longer the time series, the more comprehensive the analysis. A longer time series also gave more possibilities for approximating the maximum or “optimal”. More disaggregated measures of the heterogeneous capital stock, such as a measure of vessel size, kW, and gear size, provided a more accurate measure; typically only one of these measures of the capital stock was binding so that there was in effect only a single capital stock or a capital stock measure by a single dimension.

30. A Level 2 analysis, when target catch levels (TCL) were available, could calculate the minimum number of vessels corresponding to the TCL, based on the harvesting technology.

31. The availability of fishing time or fishing activity data in a Level 2 analysis allowed estimation of capacity on a per period basis, which could then be combined with alternative season lengths and vessel numbers to address the capacity effects of different season lengths. The issue of latent capacity¹ could be addressed by estimating capacity for the existing vessels, and assigning these estimates of capacity to the vessels with no reported landings, matching appropriate vessel characteristics and operating characteristics. However, due to the complexity of the issue of latent capacity, it needed to be addressed on a case-by-case basis.

32. A DEA analysis could incorporate environmental parameters (e.g., sea surface temperature, salinity, indices of primary productivity or convergence between different zones) and estimates of resource abundance (they were incorporated as “nondiscretionary variables”). A Level 2 analysis could also incorporate strategic behaviour of fishers, generalists versus specialists, inshore versus offshore, and other such distinctions either by separate analyses or by the use of binary or categorical variables or several other alternatives which were not discussed here.

33. A Level 2 analysis could tackle highly fluctuating resource stocks and capacity, such as those found in many small pelagic species fisheries, by dividing the analysis into separate high and low biological productivity periods or the use of categorical (binary) variables. Other regime shifts of a similar nature could be similarly accommodated.

34. Peak-to-peak and DEA needed to be widely applied to a variety of case studies so that these methods and their benefits and limitations could be more fully evaluated.

35. Qualitative information could be extremely useful to assist in the proper formulation of capacity analyses and interpretation of the results.

36. Qualitative information might be useful for assessing the likely level of exploitation of a stock or group of stocks; e.g. qualitative information on trends in catches over time, and the average size or species composition of fish caught compared to what it could or should be. Those stocks most likely to be heavily over-exploited might then be identified as the highest priority for collection of the basic data.

37. An advantage of DEA was that it could be formulated to incorporate comprehensive data, including multiple vessel attributes, stock biomass, and environmental variables.

¹ Latent capacity refers to vessels that were not currently active but were potentially active, and to vessels that were currently active at a low level

38. The Working Group recommended that FAO should obtain and distribute a manual on DEA, peak-to-peak and other relevant methods of estimating capacity; investigate possibilities for obtaining site licences for DEA software; and initiate coordination of training programmes for the application of the various methods for estimating capacity.

Common indicative standard of long-term limit capacity which would allow for international comparisons

39. The Group discussed the idea of long-term limit or critical capacity in relation to reference points, particularly Maximum Sustainable Yield (MSY) and Maximum Economic Yield (MEY). MSY was considered primarily as a result of it being adopted as a limit reference point by the Code of Conduct for Responsible Fisheries which was adopted by the FAO Conference in 1995, and in Annex II of the UN Fish Stocks Agreement.

40. It was noted that MEY was generally below MSY in relation to capacity inputs (fishing mortality and effort). The Group agreed that if economic maximisation was a key management objective, the capacity input required to generate MSY might be a useful reference point but that it should not be considered the only long-term limit or critical capacity point. The Group noted that it was not always possible to calculate MSY and that some management agencies had not adopted the idea of MSY as a limit, but that in many cases a reasonable proxy could be estimated e.g. $F_{0.1}$.

41. In conclusion, the group believed that it was useful to calculate the capacity level corresponding to MSY, but that this should be considered as an indicative upper bound on capacity, not as a limit in the sense implied by the precautionary approach which defined a limit as a boundary to be avoided with high probability. Thus, the Working Group preferred to think of MSY as a potential upper bound indicator to allow for international comparisons, but not as a critical upper bound beyond which the need to rapidly reduce capacity was critical. The Group agreed that an upper bound on capacity might be derived with respect to an appropriate proxy for MSY.

Defining short-term and long-term target capacity

42. The group discussed the rationale for defining both short-term and long-term target capacities. It was pointed out that both measures were only necessary in situations where the resource level was significantly depleted and a recovery strategy was needed to allow the stock to return to optimal conditions in order to invoke an optimal management plan. In such situations, it was clear that if capacity was measured according to the definition agreed upon i.e. in terms of catch, existing capacity, if fully utilized, may be far greater than that which the stock could withstand. However, there might be less of a need to reduce fleet size if the stock was expected to recover.

43. The Group discussed whether in situations where the fleet capacity was far greater than that which the stock could withstand, it was possible to determine long-term target capacity. The Group concluded that it was possible, but that it is not a trivial exercise. One of the main problems was to estimate how technology developments were likely to affect future capacity. Similarly, factors such as change in markets, new or different production methods would also affect capacity and were difficult to estimate and such estimates were likely to be naïve. It was argued that if we wished to predict target capacity more than a few years ahead this could be done with some confidence provided that sufficient knowledge of the population dynamics of the resource existed.

44. Recognizing that to appropriately set a target capacity either short- or long-term, it was necessary to specify a target biomass and that this might not be easy. However, the most important objective would be to develop a capacity management strategy that ensured that fleet capacity was moving in the right direction. It was important to be able to determine the magnitude of the difference between the current and target capacity in order to determine the severity of the problem, and the appropriate step size to reduce future capacity.

45. For cases of severe over-fishing, the Group discussed whether if capacity was removed from a fleet, such capacity could be re-instated at a future date when stocks had recovered. It was concluded that this was really a capacity management issue and was beyond the scope of the present meeting.

Nevertheless the group considered that this issue was an important one and that the rate of modifying capacity should be examined on a case by case basis and related to the type of resource under exploitation. Highly fluctuating resources might need a different approach than relatively stable resources.

46. The group was informed of the experience of the EU in measuring capacity in relation to resource availability. The EU was primarily concerned with physical capacity and targets were set through the EU Multi-annual guidance programmes (MAGPs) which assumed a direct relationship between fishing capacity and fishing mortality. The current MAGP is MAGP IV. Information and advice on the state of how the stocks were likely to evolve was obtained from advisory bodies, and the stocks were given a classification of either Depletion Risk, Over-fished or Fully Exploited according to predetermined criteria. According to the state of the stocks, capacity reductions under MAGP IV were derived for fleet segments exploiting the different classifications of stocks as follows:

- Depletion risk – capacity reduction 30%
- Over- exploited – capacity reduction 20%
- Fully exploited – capacity reduction 0%

47. After considerable discussion on this topic, the group concluded the following:

48. The difference between short- and long-term target capacity only mattered if the resource was currently at levels far from optimal levels (either much higher or much lower than the level corresponding to the long-run target, with the latter situation being more common).

49. In the case of resources that were currently severely depleted, there existed the possibility that current capacity was far in excess of the capacity required to optimally harvest the current resource (particularly if the stock was rebuilding), but that current capacity might be less excessive relative to the long-run rebuilt resource condition. Therefore, capacity management measures should also consider the long-run management objectives and projected resource conditions.

50. It should also be recognized that, in cases where the resource was currently at levels far from optimal levels, there were several difficulties in predicting the long-run target capacity. These difficulties related to potential changes in technology, potential changes in market conditions and therefore profitability of the species of concern, and regime shifts. The severity of the problem increased with the length of the time horizon.

51. Life history (demographic) characteristics of the stocks of concern were also relevant in determining the urgency of the need to control capacity. In stocks that could rebuild quickly (e.g. many small pelagic stocks), rapid capacity reduction might be less imperative than in cases of stocks that were relatively much slower to respond to reductions in fishing pressure (e.g. many demersal stocks).

Correspondence between output (actual and target capacity) and fishing inputs

52. Attention was drawn to the fact that the economic literature contained extensive references to the relationship between physical and production-based measures of capacity, concluding that physical capacity and its utilization provided an exact measure and directly varied with production capacity and its utilization, only when there was a linear relationship between the two. Three conditions must hold for this linear or one-to one relationship between physical and production capacity when holding the resource stocks and environmental conditions constant:

- Constant returns to scale (e.g. a 1% increase in all physical capacity inputs, yielded a 1% increase in production capacity)
- A single capital stock
- All variable inputs (those inputs whose level of use could be varied over the time period of concern) were in fixed proportions to the capital stock. The capital stock was a fixed input and one whose level could not be changed over the time period concerned.
- Constant resource size

53. When any or all of these three conditions did not hold true, then physical capacity and its

utilization did not directly measure and coincide with production capacity and its utilization. Moreover, even when these three conditions held true, but the resource stocks changed their level and/or composition, the relation between physical and production capacity might become non-linear.

54. In all cases, whether or not the direct linear relationship held between physical and production capacity, physical capacity and its utilization corresponded to the concept of capital and its utilization (the ratio of the optimal to actual capital stock).

55. While recognizing that the assumption of linearity between physical and production measures of capacity might be erroneous, the Group concluded that this uncertainty should not impede the progress currently being made, since at present, there was no specific need to make the translation from input to output measures. Capacity could be measured by either means. In addition, the Working Group recommended that more research needed to be done on the question of linking physical and production measures of capacity, but that in the meantime, the two could be treated as alternative measures of capacity and relative capacity.

Incorporation of complementary economic information in the measurement and evolution of capacity

56. The Group noted that the definition of capacity contained in the Technical Working Group was primarily a technical definition, not an economic definition, and that the Technical Working Group recommended that further work be conducted to develop an economic definition.

57. It was pointed out to the group that the benefits of an economic definition were that it provided an explicit mechanism for incorporation of prices and costs and the firms' changes in the mixes of inputs and outputs when market conditions, biomass or environmental parameters changed. It provided an explicit mechanism for incorporation of pertinent social objectives, and directly addressed the incentives to invest or disinvest the capital stock when the firm or vessel exceeded or fell below the economic measure of capacity. The drawbacks were that relevant economic data, especially costs were usually lacking, it was not commonly applied by national governments in other industries, and was more difficult to estimate.

58. The Working Group also emphasized that the production capacity implicitly incorporated economic factors in the sense that the data from a fishery reflect biological and environmental decisions related to costs, profits, and biological and environmental conditions. Thus the mix and level of species caught reflected the market prices and operating costs and biomass and the level and type of capital stock reflected the expected biomass, profits and costs of capital. The Group also emphasized that the production capacity was a "best practice frontier", that is, it reflected the production capacity of the most efficient vessels for the time period analysed.

59. The group had access to a draft report of a meeting of the US National Excess Capacity Task Force on defining and measuring fishing capacity, in which two economic definitions of capacity were proposed. These were as follows:

Economic definition

60. The traditional definition of economic capacity, based on cost minimization, was that level of output of fish caught over a period of time (year, season) where short-run and long-run average costs are equal, for a given fleet size and composition, resource condition, market condition, state of technology and other relevant constraints.

Alternative economic definition

61. Modified definitions of economic capacity based on alternative objective functions were those levels of output of fish caught over a period of time (year, season) where objectives such as profits or net social benefits were maximised for a given fleet size and composition, resource condition, market condition, state of technology and other relevant constraints.

62. The group agreed that the incorporation of economic data into capacity measurement according to

either of the two definitions given above was possible in principle. However, in practice the situation was rather different since at this point in time, appropriate data were either unavailable or non-existent.

Indicators and methods to measure fishing capacity: the case for specific fisheries

Fisheries based on highly migratory resources.

63. The group discussed the measurement of capacity for highly migratory resources. It was pointed out that highly migratory species were exploited by many countries and by a variety of gears. Many were also shared stocks and in addition, several species might be exploited in the same fisheries at the same time. However, the impact of such fisheries on the different stocks could vary considerably. The group noted that while the fleet capacity might be at appropriate level for the fishery's target stock, if the stock was in a healthy state, the capacity with regard to the by catch species might be excessive.

64. The group considered that in such circumstances, estimation of the appropriate level of capacity was not straightforward. In addition the interactions between different gear types, coastal fisheries and offshore fisheries were further complicating factors.

65. Since highly migratory stocks were usually shared stocks, the Group recognized that there was a need to foster greater cooperation between interested parties exploiting highly migratory resources in particular through regional fisheries organizations. Such cooperation should include the collection and reporting of appropriate data to measure and compare capacity from nations exploiting highly-migratory resources.

Fisheries showing high fluctuations in stock abundance or availability

66. With reference to fisheries showing high fluctuations in stock abundance or availability, the group recognized that most highly fluctuating resources tended to be highly dependent on spawning success and subsequent recruitment. In addition, most of these stocks tended to be short-lived. Furthermore, spawning success and subsequent recruitment tended to be highly correlated with environmental variables. Since environmental effects could vary cyclically, causing regime shifts in spawning and/or recruitment success, the group discussed how capacity should be assessed in such circumstances, and agreed that a different assessment should be carried out under each of these circumstances.

67. The Working Group therefore recommended that capacity analysis should accommodate the situation where environmental conditions could be considered in at least two phases, favourable and unfavourable, i.e., the existence of regime shifts should be recognized.

68. The group also discussed the issue of latent capacity, which referred to vessels that were not currently active but were potentially active, and to vessels that were currently active at a very low level. In other words, fleets of such vessels had a high potential capacity with respect to a resource that was currently at a low level, if resources returned to a high level because of favourable environmental conditions.

69. The Group concluded that special attention should be paid to the estimation of latent capacity which could be extremely important in highly-fluctuating resources.

70. A further point of discussion was how fishermen reacted to changes in resource availability or catch constraints due to changes in resource availability. The group concluded that the behaviour of fishermen with respect to strategies and tactics employed to deal with highly fluctuating resources might be an important factor influencing the determination of capacity. For example, the level of mobility of fishermen and their ability to switch to alternative resources could be a significant factor in capacity measurement.

Small-scale fisheries

71. Small-scale fisheries are characterised by many simple small gear units and many participants which were widely dispersed. The Group agreed that this posed significant and often complex problems in the measurement of capacity, primarily because of problems in data acquisition. Cultural factors and

other socio-economic issues might also be relevant to the calculation of capacity. In addition there might often be significant interactions between industrial fisheries and small-scale (artisanal) fisheries as well as biological interactions. Such interactions were further complicating factors.

72. Another characteristic of small-scale fisheries was that they had limited autonomy, meaning that capacity utilization could be highly variable and limited by external factors such as localized weather conditions.

73. The Group recognized that for many small-scale fisheries, data on fishing units and catches were either incomplete or non-existent, and that such data were fundamental to any quantitative estimate of capacity. Recognizing that data would not be easily obtained, the Group recommended that for the case of small-scale fisheries, data acquisition could be based on sampling rather than census. However, the additional precision gained from more complete information was also acknowledged. It was also noted that for the estimation of fishing capacity in small-scale fisheries, the number of participants or gear units might be more important than the number of vessel units.

74. The Group recommended estimation of biomass of the resources exploited by small-scale fisheries. Measures of capacity should take into account interactions between industrial and small-scale fisheries as well as biological interactions.

Shared stock Fisheries

75. The Group discussed the main characteristics of shared stock fisheries which were those exploited by more than one country. This represented a special case and the group agreed that international cooperation in the collection and reporting of data for the measurement of capacity was essential if reliable measures of capacity were to be obtained.

76. Furthermore the Group agreed that nations exploiting shared resources should be able to provide comparable estimates of capacity, thereby requiring such nations to collect information on fleets and catches to a similar standard. The collection of similar data would allow direct comparisons between the capacity estimates for different participating nations.

77. The Working Group recommended that statistical methods and protocols used for data collection, analysis and reporting should be standardized to the extent possible so as to make information and measurements comparable.

Multi-species fisheries.

78. The Group recognized that multispecies fisheries present several complexities. In such fisheries several stocks were fished in a given area and several different fleets and gears might compete for these stocks. This represented a technical interaction between competing fleets and gear types but the group also recognized that predator-prey or ecosystem effects were a further complicating factor in measuring capacity and might need to be taken into account. For example, small pelagics tended to be highly fluctuating stocks and often formed the base of the food chain.

79. The Group considered that one of the important problems in relation to multispecies fisheries was the difficulty in estimating capacity when several species were being exploited simultaneously by the same fishery but with sometimes varying exploitation rates.

80. The Group considered that changing catch composition over time from the same multispecies fisheries might provide a useful indication of changing exploitation rates and that this might be an important factor to be considered in any capacity estimation. The Working Group therefore recommended that the composition of the catch should be considered in assessing capacity since it might provide useful information on the state of the fishery over time. In addition, there was a need to consider incidental catch, discards and seasonal variations.

81. The Working Group also recommended that careful thought be given to the appropriate level of aggregation for species in multispecies fisheries.