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Report of the

FAO EXPERT WORKSHOP ON ASSESSMENT AND MONITORING OF AQUACULTURE SECTOR PERFORMANCE

Gaeta, Italy, 5–7 November 2012

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Report of the

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PREPARATION OF THIS DOCUMENT

This document is the final report of the FAO Expert Workshop on Assessment and Monitoring of Aquaculture Sector Performance, held in Gaeta, Italy, from 5 to 7 November 2012. The report contains a record of the meeting proceedings, summaries of presentations and discussions, and the background documents.

The report was prepared by Junning Cai and Nathanael Hishamunda of the FAO Fisheries and Aquaculture Department with the assistance of Elisabetta Martone (FAO Consultant) and Neil Ridler (FAO Consultant) as well as contributions from workshop participants.

The support from various people and organizations to the workshop is acknowledged as follows: the NEPAD-FAO Fish Programme (NFFP) for the main funding support; Elisabetta Martone for technical and logistic support; Indra Gondowarsito and Romina Toscano of FAO for logistic support; and invited experts for participation and technical support.

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ABSTRACT

The FAO Expert Workshop on Assessment and Monitoring of Aquaculture Sector Performance was held in Gaeta, Italy, from 5 to 7 November 2012 to discuss the methodologies and techniques of, and to share global, regional and national experiences in, assessing and monitoring the performance of aquaculture.

Session 1 of the workshop included 28 presentations under 6 thematic topics: sharing regional and national experiences; data and statistics; aquaculture's contribution to food and nutrition security; economic performance of aquaculture; environmental performance of aquaculture; and measuring the net impact of aquaculture. The information, knowledge and insights provided by the presentations are summarized in an appendix to the report.

Session 2 of the workshop introduced an FAO initiative for developing a user-friendly tool to facilitate the assessment and monitoring of aquaculture sector performance. The World Aquaculture Performance Indicators (WAPI) tool is intended to compile, generate and provide easy access to quantitative indicators on aquaculture sector performance at the national, regional and global levels. A background document on the WAPI tool is provided in an appendix to this report. A prototype WAPI tool was presented at the workshop for comments, suggestions and potential collaboration. The report documents the feedback of workshop participants on the draft WAPI.

Session 3 of the workshop included brainstorming discussions by working groups on three thematic topics: aquaculture's contribution to food and nutrition security; its socio-economic performance; and its environmental performance. Tables in the report summarize the results of these discussions

The report also summarizes a number of indicators on various dimensions of aquaculture sector performance and various data sources. Effective assessment and monitoring of aquaculture sector performance entails integration of indicators, data and issues as three key elements. The summary at the end of the report discusses how the WAPI tool can facilitate such integration.

CONTENTS

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ABBREVIATIONS AND ACRONYMS

AFSPAN	Aquaculture for Food Security, Poverty Alleviation and Nutrition
AHP	analytical hierarchy process
AIIS	Agriculture Industrial Information System
ANAF	Aquaculture Network for Africa
AU	African Union
BCR	benefit–cost ratio
CBA	cost–benefit analysis
CCRF (or Code)	Code of Conduct for Responsible Fisheries
COFI	Committee on Fisheries (FAO)
CPC	Central Product Classification
CWP	Coordinating Working Party
DRR	disaster risk reduction
DRM	disaster risk management
EAF	ecosystem approach to fisheries
EAA	ecosystem approach to aquaculture
EAPI	European Aquaculture Performance Indicators
EEZ	exclusive economic zone
EPI	Environmental Performance Index
EU	European Union
FAO	Food and Agriculture Organization of the United Nations
FAO/FI	FAO Fisheries and Aquaculture Department
FBS	food balance sheet
FCR	feed conversion ratio
GAPI	Global Aquaculture Performance Index
GDP	gross domestic product
GE	general equilibrium
GHG	greenhouse gas
GVA	gross value added
HS	Harmonized System
IAA	integrated aquaculture–agriculture
IFPRI	International Food Policy Research Institute
ILO	International Labour Organization
IMF	International Monetary Fund
IMTA	integrated multitrophic aquaculture
JRC	Joint Research Centre
LIFDC	low-income-food-deficit country
NACA	Network of Aquaculture Centres in Asia-Pacific
NEPAD	New Partnership for Africa’s Development
NFFP	NEPAD-FAO Fish Programme
NOAA	National Oceanic and Atmospheric Administration
NOK	Norwegian krone
Norad	Norwegian Agency for Development Cooperation
OECD	Organisation for Economic Co-operation and Development
PE	partial equilibrium
PEF	production efficiency
PDR	processing–distribution–retailing
SARNISSA	Sustainable Aquaculture Research Networks in Sub-Saharan Africa
SEAFDEC/ASEAN	Southeast Asian Fisheries Development Center / Association of Southeast Asian Nations
SEEA	system of environmental and economic accounting
SIA	social impact assessment
SNA	System of National Accounting

SOFIA	*The State of World Fisheries and Aquaculture*
UAPB	University of Arkansas at Pine Bluff
UPC	universal product code
USDA	United States Department of Agriculture
USD	United States dollar
WAPI	World Aquaculture Performance Indicators
WB	World Bank
WCO	World Customs Organization
WHO	World Health Organization
WP	work package

BACKGROUND

1. Aquaculture is a fast-growing sector with complex environmental, economic and social impacts. Assessment and monitoring of such impacts is essential for stakeholders in both the public and private sectors to conduct evidence-based policy-making and/or sector management. However, the lack of information and knowledge (especially quantitative indicators) about aquaculture sector performance has been a global and perennial issue. The issue is especially critical for regions with a less developed aquaculture sector (e.g. Africa).

2. At the request of FAO Members, the FAO Fisheries and Aquaculture Department has initiated activities aimed at assessing and monitoring aquaculture sector performance globally, regionally and nationally. Similar efforts are under way in some regions. An example is the Africa region, where, through the NEPAD-FAO Fish Programme (NFFP), there is an ongoing initiative to assess and monitor the overall social and economic importance of fisheries and aquaculture in the region. The NFFP has requested assistance from FAO in this endeavour.

3. While discussing the way forward regarding the Agenda Item Five (Assessing and monitoring aquaculture sector performance: importance, issues and challenges)[1] of the sixth Session of the FAO COFI Sub-Committee on Aquaculture, which was held in March 2012 in Cape Town, South Africa, FAO Members present at this meeting recommended the FAO Secretariat to coordinate with other countries and institutions with the aim of sharing experiences and techniques on assessing and monitoring the performance of aquaculture.[2]

4. In response to these requests, the FAO Expert Workshop on Assessment and Monitoring of Aquaculture Sector Performance was held in Gaeta, Italy, from 5 to 7 November 2012, with the aim of discussing the methodologies and techniques of, and sharing global, regional and national experiences in, assessing and monitoring the performance of aquaculture.

PARTICIPANTS

5. The workshop was attended by 27 experts from a wide range of disciplines and geographical areas. The information on the participants is provided in Appendix 1.

OPENING OF THE WORKSHOP

6. The workshop was opened by the Chairperson, Mr Peter Gullestad (Norway), who welcomed the participants and introduced the workshop agenda.

AGENDA OF THE WORKSHOP

7. The agenda of the workshop, which is provided in Appendix 2, included three technical sessions on assessment and monitoring of aquaculture sector performance.

8. Session 1, intended to share existing experience, data and information on the subject, included a number of presentations under different thematic topics.

9. Session 2 included a presentation and discussion on the World Aquaculture Performance Indicators (WAPI) – A User-Friendly Tool.

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[1] FAO. 2012. *Assessing and monitoring the aquaculture sector performance: importance, issues and challenges* [online]. Committee on Fisheries. Sub-Committee on Aquaculture. Sixth Session Cape Town, South Africa, 26–30 March 2012. COFI: AQ/VI/2012/5. [Cited 9 December 2013]. ftp://193.43.36.92/FI/DOCUMENT/COFI/Cofi_aq/2012/5e.pdf

[2] FAO. 2012. *Report of the sixth session of the Sub-Committee on Aquaculture. Cape Town, South Africa, 26–30 March 2012. Rapport de la sixième session du Sous-Comité de l'aquaculture. Le Cap, Afrique du Sud, 26-30 mars 2012. Informe de la sexta reunión del Subcomité de Acuicultura. Ciudad del Cabo, Sudàfrica, 26-30 de marzo de 2012*. FAO Fisheries and Aquaculture Report / FAO Rapport sur les pêches et l'aquaculture / FAO Informe de Pesca y Acuicultura No. 1006. Rome/Roma. 59 pp. (also available at www.fao.org/docrep/016/i2765t/i2765t.pdf).

10. Session 3 included brainstorming discussion by working groups on practical and integrated ways to assess and monitor aquaculture sector performance.

OBJECTIVES OF THE WORKSHOP

11. At the end of the opening session, Mr Nathanael Hishamunda (FAO/FI) gave a brief presentation to introduce the background and objectives of the workshop. He highlighted a series of constraints and challenges in assessing and monitoring aquaculture sector performance, which include: (i) identifying appropriate indicators; (ii) developing solid frameworks and models to measure them; (iii) the lack of user-friendly tools to quantify indicators; (iv) the lack of adequate data nationally, regionally and globally; (v) limited accuracy of estimates of missing data; and (vi) limited financial resources for census or surveys for data collection. He believed that the results of the workshop would be helpful to address these issues.

12. He explained that the overall objective of the workshop was to provide a platform for international experts from different disciplines to share information, techniques and experiences in assessment and monitoring of the economic, social and environmental performance of aquaculture development in different regions. The knowledge, insights and synergy generated in the workshop would facilitate assessment and monitoring of aquaculture sector performance, especially in regions (such as Africa) where aquaculture development is less advanced.

13. He highlighted that a particular objective of the workshop was to seek experts' comments, suggestions and collaborations on improving, enriching and expanding a user-friendly tool for assessing and monitoring aquaculture sector performance. Specifically, the experts were asked to advise how to adjust and adapt the tool to the specific needs of a country or region (e.g. Africa) in assessing and monitoring the performance of its aquaculture sector.

SESSION 1: SHARING EXPERIENCES, DATA AND INFORMATION

14. With the aim of sharing existing experiences, data and information on aquaculture development, Session 1 of the workshop included 28 presentations under six thematic topics. Topic 1 focused on sharing regional or national experiences in assessing and monitoring aquaculture sector performance. Topic 2 focused on data and statistics on aquaculture. Topics 3, 4 and 5 examined aquaculture's social, economic and environmental performance, respectively. Topic 6 focused on measuring the net impact of aquaculture.

15. Information about the title and presenters of each presentation is provided below. A synopsis of the 28 presentations is provided in Appendix 3.

Thematic Topic 1: Regional or national experiences

16. Five presentations were delivered under Thematic Topic 1 to share the experiences of the European Union (Member Organization), Africa, China, Norway and the United States of America, respectively, in the assessment and monitoring of aquaculture sector performance.

- Presentation 1: European Aquaculture Performance Indicators (EAPI), by
  Mr Fabrizio Natale from the Joint Research Centre (JRC) of the European Commission.
- Presentation 2: Assessment of aquaculture in Africa, by
  Mr Gertjan DeGraaf (FAO Consultant).
- Presentation 3: Aquaculture industry information system in China, by
  Mr Yongming Yuan from the Freshwater Fisheries Research Center in China.
- Presentation 4: Aquaculture performance indicators – Norwegian examples, by
  Mr Peter Gullestad from Directorate of Fisheries (Norway).
- Presentation 5: Assessing the aquaculture sector in the United States of America, by
  Mr Alan Lowther from National Oceanic and Atmospheric Administration (NOAA) of the United States of America.

Thematic Topic 2: Data and statistics on aquaculture

17. Four presentations were delivered under Thematic Topic 2 to discuss issues related to data and statistics on fish production, trade, consumption and employment.

- Presentation 6: FAO data and statistics on aquaculture production and resource use, by Mr Xiaowei Zhou from FAO Fisheries and Aquaculture Department (FAO/FI).
- Presentation 7: FAO data and statistics on utilization, trade and consumption, by Ms Stefania Vannuccini (FAO/FI).
- Presentation 8: FAO data and statistics on employment in aquaculture, by Mr Fernando Jara (FAO/FI).
- Presentation 9: Data on fish consumption based on store-level scanner data, by Mr Madan Dey from University of Arkansas at Pine Bluff (United States of America).

Thematic Topic 3: Aquaculture's contribution to food and nutrition security

18. Six presentations were delivered under Thematic Topic 3 to discuss issues related to aquaculture's contribution to food and nutrition security.

- Presentation 10: Aquaculture's contribution to food and nutrition security, by Ms Bente Torstensen from National Institute of Nutrition and Seafood Research (Norway).
- Presentation 11: Fish - a healthy alternative; farmed fish- a good choice, by Mr Jogeir Toppe (FAO/FI).
- Presentation 12: Fish to 2030 - A WB/IFPRI/FAO/UAPB research effort, by Mr Madan Dey from University of Arkansas at Pine Bluff (United States of America).
- Presentation 13: Fish model and projections in OECD-FAO Agricultural Outlook, by Ms Stefania Vannuccini (FAO/FI).
- Presentation 14: Estimating future fish supply-demand gaps, by Mr Junning Cai (FAO/FI).
- Presentation 15: AFSPAN: An EU-project on the socio-economic impacts of aquaculture, by Mr Trond Björndal from University of Portsmouth (United Kingdom) and Mr Koji Yamamoto (FAO/FI).

Thematic Topic 4: Economic performance of aquaculture

19. Four presentations were delivered under Thematic Topic 4 to discuss issues related to the assessment and monitoring of the economic performance of aquaculture.

- Presentation 16: Aquaculture's contribution to value addition and GDP, by Mr PingSun Leung from University of Hawaii at Manoa (United States of America).
- Presentation 17: Aquaculture's contribution to employment and poverty alleviation, by Mr Neil Ridler from University of New Brunswick (Canada).
- Presentation 18: Comparing value chains in fisheries and aquaculture, by Mr Jose Fernández-Polanco from Universidad de Cantabria (Spain).
- Presentation 19: GLOBEFISH – a private sector's point of view, by Mr Jose Estors-Carballo (FAO/FI).

Thematic Topic 5: Environmental performance of aquaculture

20. Five presentations were delivered under Thematic Topic 5 to discuss issues related to the assessment and monitoring of the environmental performance of aquaculture.

- Presentation 20: Developing aquaculture performance indicators, by Ms Doris Soto (FAO/FI).

- Presentation 21: Environmental and resource constraints in aquaculture, by
  Mr Trond Björndal from University of Portsmouth (United Kingdom).
- Presentation 22: Aquaculture and climate change: objectives and performance criteria, by
  Mr James Muir from University of Stirling (United Kingdom).
- Presentation 23: Water use in aquaculture, by
  Ms Daniela Ottaviani (FAO Consultant).
- Presentation 24: Global Aquaculture Performance Index (GAPI), by
  Ms Jennifer Gee from University of Victoria (Canada).

Thematic Topic 6: Measuring the net impact of aquaculture

21. Four presentations were delivered under the Thematic Topic 6 to discuss issues related to the measuring of the net impact of aquaculture.

- Presentation 25: Different approaches on measuring the net impact of aquaculture, by
  Mr Neil Ridler from University of New Brunswick (Canada
- Presentation 26: Environmental performance of aquaculture: trade-offs and net impact, by
  Mr John Hambrey from Hambrey Consulting (United Kingdom).
- Presentation 27: Impact of aquaculture under various policy scenarios, by
  Mr Madan Dey from University of Arkansas at Pine Bluff (United States of America).
- Presentation 28: System of environmental and economic accounting (SEEA), by
  Ms Daniela Ottaviani (FAO Consultant).

SESSION 2: WORLD AQUACULTURE PERFORMANCE INDICATORS (WAPI): A USER-FRIENDLY TOOL

22. This session includes a presentation of the WAPI tool followed by plenary discussion.

23. Prior to the workshop, a document on the WAPI tool was distributed to the participants. The document is attached in Appendix 4.

Presentation of the WAPI tool

24. Mr Junning Cai (FAO/FI) presented the World Aquaculture Performance Indicators (WAPI), which is a user-friendly, MS Excel-based tool initiated by FAO/FI to facilitate assessment and monitoring of aquaculture sector performance.

25. The presentation noted that quantitative information on aquaculture sector performance is generally lacking and when available, tends to be scattered in the literature, which leads to available information underutilized and sometimes misused. Misusing data from different sources (or even the same source) to create incorrect or misleading indicators is not an uncommon phenomenon.

26. The main objective of the WAPI tool is to compile, generate and provide easy access to quantitative information on aquaculture sector performance at the national, regional and global levels. The WAPI tool is intended to become a user-friendly instrument that helps experts utilize data and information from various sources to assess and monitor aquaculture sector performance in social, economic, environmental and governance terms and detect important trends in parameters of interest in the sector.

27. The primary users of the WAPI tool would be professionals in the aquaculture and fisheries sector, including policy-makers, planners, managers, advisors, analysts, researchers, students, etc. All users of FAO FishStat[3] are potential users of the WAPI tool.

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[3] Available at www.fao.org/fishery/statistics/software/fishstat/en

28. The WAPI tool is intended to become a shareware that provides a way for professionals to capitalize their sporadic efforts into standardized templates for convenient use not only by themselves but also by others.

29. The WAPI tool can also provide a venue for detailed analyses and information that are unable to be accommodated by technical reports or journal articles.

30. The potential data sources of the WAPI tool include FAO statistics, international and national official statistics databases, non-official databases, case studies, technical reports, etc.

31. The presentation demonstrated a prototype version of the WAPI tool, which was developed by FAO based on various official and/or publically available data sources, including among others: (i) FAO Food Balance Sheet; (ii) FishStat; (iii) FAO-INFOOD data on nutrition; (iv) FAO Statistics Division's data on food security; (v) UN Comtrade; (vi) UN Population; (vii) data from the International Labour Organization (ILO) on employment; (viii) World Economic Outlook database of the International Monetary Fund (IMF); (ix) World Development Indicators of the World Bank (WB); (x) GAPI; (xi) China Fishery Statistics Yearbook.

32. The draft WAPI tool covers 233 countries (or territories), 42 country groups (regions, subregions, etc.) and major fish species groups (freshwater finfish, diadromous finfish, marine finfish, crustacean, molluscs and cephalopods).

33. The draft WAPI tool includes 72 templates in two sections. Section I includes templates on aquaculture's social, economic and environmental performance in different countries or country groups, while Section II contains templates on the status and trend of aquaculture development in different countries and country groups (see Appendix 4 for details).

34. The draft WAPI tool uses various templates to analyse the data and statistics included and to present the resulting quantitative indicators in well-structured tables and graphs. The presentation used examples to demonstrate that: (i) simple analyses such as comparisons across time, countries, species and products have been standardized for many indicators in the draft tool; and (ii) the draft tool also includes some advanced analysis such as measuring correlations between variables and projection of fish demand and supply in the future.

35. The WAPI tool was designed to facilitate modifications and updating. Replacing or appending new data in the data templates would automatically update all the tables and graphs in the related indicator templates and, hence, lead to new inferences, policy and management advice on the sector.

36. The draft tool in its current status can be used to help generate policy briefs, factsheets, and other thematic reports for policy-making or sector management. However, there is still plenty of room for improvement and expansion:

- Tables and graphs in the tool can be linked to the corresponding sources of information and data for users to obtain more contextual information.
- The tool can be used to gain broader information and deeper understanding of specific aspects of aquaculture sector performance for a given country, region or the entire world.
- As the tool consolidates enough information, templates can be developed to address specific policy or management issues.
- It is also feasible to develop or incorporate weighting schemes, performance index or other processes to measure the net impact (i.e. overall performance) of the aquaculture sector.

37. The presentation noted that the development of the WAPI tool would be a long-term, continuing, and improving-by-using process entailing coordinated efforts by many people. The presentation highlighted some thoughts on the strategy and action plan needed to facilitate the development of this valuable public good (see Appendix 4 for details).

Feedback from the experts

38. The experts' comments and suggestions on the WAPI tool are summarized as follows.[4]

General

39. In general, the experts recognized the importance of assessing and monitoring the social, economic and environmental performance of aquaculture and commended the good and considerable work undertaken by FAO to elaborate the WAPI tool.

Data and statistics

40. It was noted that accurate and reliable data are essential to functionalize the templates included in the WAPI tool, without which the templates would be like "castles in the air".

41. It was recommended that FAO Members be encouraged to collect relevant data and share them with FAO, which would enhance the usefulness of meaningful indicators for all Members.

42. It was deemed important for the WAPI tool to use already published data or data referenced by reliable sources such as international organizations and research publications.

43. While it was suggested that including data from less official and/or ad hoc sources could add value to the WAPI tool, caution has been raised against disseminating data from less official sources in the WAPI tool without proper quality control. The need to safeguard FAO standards and protect FAO's recognized credibility against inaccurate and/or misleading data and statistics was emphasized.

Scope and functions

44. It was recommended that the WAPI tool should start with a set of core (or key) indicators at the country level because it would make the tool more user friendly and less data demanding. The tool should suggest ways and standards of collecting necessary data for quantifying the core indicators and become a dissemination tool of the core indicators.

45. It was pointed out that even for core indicators, the lack of data remains problematic, especially if a monetary value is to be put on environmental impacts.

46. It was suggested that currently the WAPI tool should focus more on the supply side of the sector because the lack of demand for fish is not an issue now and is not likely to be one in the near future.

47. It was suggested that, in addition to the social, economic and governance dimensions, the WAPI tool should also cover the governance dimension of aquaculture; the Code of Conduct for Responsible Fisheries self-assessment organized by FAO[5] could provide useful information in this regard.

48. It was recognized that the WAPI tool is an effective instrument for calculating simple indicators (e.g. aquaculture's share in gross domestic product or total employment) and conducting trend analyses across countries, species and products.

49. It was questioned whether it is worthwhile to develop WAPI templates to evaluate the net impact of aquaculture because assessing trade-offs tends to be a political process.[6]

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[4] The summary also includes the comments and suggestions provided by the experts during Session 3 (i.e. the brainstorming session).
[5] See Presentation 20 by Doris Soto for some discussion.
[6] See Presentation 26 by John Hambrey for some relevant discussion.

50. It was suggested that baselines and/or thresholds be established to make the indicators in the WAPI tool more meaningful and useful to facilitate decision-making, especially policy-making.

51. It was recognized that simple gap analyses on future national fish demands and current production from aquaculture could be done with the WAPI tool. However, it was suggested that the WAPI tool should avoid drawing misleading conclusions based on simple forecasting models (e.g. linear extrapolation of future production based on the historical trend). It was suggested that the WAPI tool could be a platform to present the forecasting results of more sophisticated forecasting models.[7]

52. In general, it is recommended to enhance the capacity of the WAPI tool by linking it to other existing models/tools for assessing and monitor aquaculture performance.

53. It was noted that the assessment framework laid out in the WAPI tool and the information gaps identified by it could facilitate data collection and make it more purposeful; the tool could become a vehicle to facilitate data dissemination from national to regional to global level.

54. It was suggested that regional, national and sectoral "WAPI" tools be developed to consolidate and utilize the large amount of data that exist but have not been accessed by a wide range of potential beneficiaries.

Development and maintenance

55. It was noted that the data and indicators included in the WAPI tool should be properly explained and referenced.

56. In light of the amount of data and statistics that the WAPI tool attempts to compile and analyse, there were concerns over its viability considering the large amount of effort needed for its development and maintenance (data compilation, quality control, updating, etc.).

57. It was suggested to break the gigantic prototype WAPI tool into various components. It was believed that simpler, more tailor-made WAPI components equipped with substantial data would be easier to develop and maintain, more user friendly, and more attractive to potential users.

58. It was suggested that the development of WAPI components could follow a bottom-up process that starts with developing WAPI tools for specific countries or regions.

59. It was suggested that the WAPI tool should be linked to other ongoing food and nutrition security initiatives.

60. The Aquaculture Network for Africa (ANAF) and FISHNET AFRICA were recommended as potential partners in Africa for such efforts. It was also noted that regional fishery bodies and regional economic commissions could be potential partners in the long run.

61. In general, it was recognized that partnership is the key to the development of the WAPI tool. The potential partners include other international organizations and research communities.

SESSION 3: BRAINSTORMING DISCUSSION

62. The experts were divided into three working groups for three topics on aquaculture: (1) food and nutrition security; (2) socio-economic performance; and (3) environmental performance (Table 1).

63. The experts in each group were asked to identify "issues" (i.e. why assess and monitoring), "indicators" (i.e. what to assess and monitor), "methods" (i.e. how to assess and monitor) and "collaborators" (i.e. who assesses and monitors) related to the respective topic.

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[7] It is worth noting that Template 68 in the draft WAPI tool (see Appendix 4) presents the demand projections estimated by a sophisticated econometric model.

64. The results of the brainstorming discussion by the three working groups are summarized as follows.[8]

TABLE 1

Composition of the working groups

Working Group 1: Food and nutrition security	Working Group 2: Socio-economic performance	Working group 3: Environmental performance
• Torstensen, Bente (Chair) • Toppe, Jogeir (Rapporteur) • Hasan, Mohammad • Hishamunda, Nathanael • Martone, Elisabetta • Muir, James • Ridler, Neil • Vannuccini, Stefania • Yamamoto, Koji	• Leung, PingSun (Chair) • DeGraaf, Gertjan (Rapporteur) • Estors Carballo, Jose • Fernández-Polanco, José • Jara Senn, Fernando • Lowther, Alan • Dey, Madan • Natale, Fabrizio • Yuan, Yongming	• Gullestad, Peter (Chair) • Cai, Junning (Rapporteur) • Björndal, Trond • Gee, Jennifer • Hambrey, John • Ottaviani, Daniela • Zhou, Xiaowei

Aquaculture's contribution to food and nutrition security (Working Group 1)

65. The contribution of aquaculture to food and nutrition security is one of the most crucial dimensions of aquaculture sector performance. In terms of food supply, access and quality, Working Group 1 identified key issues and suggested main indicators as summarized in Table 2.

TABLE 2

Aquaculture's contribution to food and nutrition security

<table>
<tr><th>Issues on food supply</th><th>Indicators</th><th>Methods</th></tr>
<tr><td>Availability of fish</td><td>• Fish production (volume and value)
• Share of low-value species in fish production
• Per capita fish consumption
• Number of fish farms
• Expected future fish production</td><td rowspan="5">• Improving data collection (e.g. breakdown by species and quality)
• Conducting farm surveys
• Obtaining data from existing databases (e.g. databases on food composition, contaminant concentration, health and disease control)
• Gathering data and information from sector planning documents</td></tr>
<tr><td>Fish trade</td><td>• Fish export (volume and value)
• Fish import (volume and value)</td></tr>
<tr><td>Volatility of fish supply</td><td>• Variation of fish production over time</td></tr>
<tr><th>Issues on food access</th><th>Indicators</th></tr>
<tr><td>Affordability of fish</td><td>• Employment
• Per capita income
• Gini coefficient
• Intrahousehold distribution
• Per capita fish consumption
• Local fish price
• Cost of fish relative to other protein sources</td></tr>
</table>

[8] Further comments and suggestions on the WAPI tool provided by the experts during the brainstorming session were incorporated in the summary presented in the "Feedback from the experts" section above.

Adequacy of infrastructure	• Features of fish supply network • Policies on (promoting) fish consumption (e.g. through targeted feeding programmes)	
Fish distribution and marketing	• Number of ice plants or cold storages	
Role of subsistence fish farming	• Amount of non-marketed output	
Issues on food quality (especially the ability to deliver needed nutrients)	**Indicators**	
Malnutrition	• Per capita food consumption level • Contribution of fish to recommended dietary energy and nutrient intakes	
Fish handling and losses/waste	• Number of ice plants or cold storages • Number of fish processing facilities • Level of fish post-harvest spoilage	
Quality of aqua feed	• Nutrient contents and quality of aqua feed	
Contamination of fish products	• Contribution of fish to tolerable weekly intake of contaminants	

66. Working Group 1 also highlighted several strategic areas important to increasing the contribution of aquaculture to food and nutrition security, including: (1) awareness of the nutrition value of fish, (2) research and development, and (3) policy formulation.

Aquaculture's socio-economic performance (Working Group 2)

67. The issues identified and indicators suggested by Working Group 2 on aquaculture's socio-economic performance are summarized in Table 3.

TABLE 3

Aquaculture's socio-economic performance

Issues	Indicators	Methods
Contribution to value addition and gross domestic product (GDP) (a key factor often considered in high-level policy-making)	• Ratio between aquaculture's direct value added and GDP • Ratio between aquaculture's "total value added" (i.e. direct plus indirect) and GDP	• Sample-based survey based on properly selected sampling frame • Census if funding available • More detailed survey or census by region if funding available • Using "derived indicators" (e.g. growth rate, variance) to examine the time trends and variability of the basic indicators
Contribution to employment (a key factor often considered in high-level policy-making)	• Number of workers (full-time, part-time or occasional) employed in aquaculture activities • Number of workers employed in the upstream and downstream industries • Aquaculture's value added per worker by employment strata (as a measure of labour productivity)	

Issues	Indicators	Methods
Contribution to livelihoods (which should be assessed with consideration of progress in development and in comparison with the situation in other sectors)	• Labour productivity (e.g. value added per worker) • Average labour income (e.g. average unit labour cost)	
The level, variability and potential of the productivity (also known as yield) of aquaculture in terms of different natural resources (e.g. land and water)	• Land productivity (kg/ha/year) • Water productivity (kg/m^3/year)	

Aquaculture's environmental performance (Working Group 3)

68. The issues identified and indicators suggested by Working Group 3 on aquaculture's environmental performance are summarized in Table 4.

TABLE 4

Aquaculture's environmental performance

Issues	Indicators	Methods
Competition in the use of land by different sectors	• Efficiency of land use in aquaculture (e.g. ha/tonne of production) • Efficiency of land use in alternative activities	• Gathering data on land use in aquaculture by species and production systems. One difficulty is defining land use by species for integrated systems. • Gathering GIS data based on remote sensing technology. One challenge is how to utilize GIS data in decision-making. • Norway's experience indicates that location tends to be more important than space in open-ocean aquaculture. • The suggested land efficiency indicators may not be applicable to non-competitive land use in aquaculture (rice field, arid land, etc.). For example, in China, fish production from rice fields is not included in the calculation of average yield. • Use of the value (instead of size) of land to measure efficiency of land use may be useful but would be difficult because of measurability of land value.
Water pollution	• Biochemical oxygen demand (BOD) • Chemical oxygen demand (COD)	• A large amount of data are needed to estimate BOD or COD at the country level because they tend to vary across different sites. • One challenge is how to use BOD or COD to facilitate decision-making as different values are appropriate for different sites.

Issues	Indicators	Methods
Aquaculture development within environmental capacity	• Colour of the surrounding water for aquaculture activities as an indicator of eutrophication	• Although there are many difficulties in measuring the carrying capacity of the environment, there are ways to determine thresholds in local areas for monitoring regimes. • Using “trial and error” to identify indicators and introduce management regime. • Asking countries to provide data and share experiences in management of environmental capacity.
Intensive use of energy in some farming systems (e.g. intensive pond culture, marine cage culture)	• Use of energy in aquaculture as compared with the use in other food producing activities	• Data may be available for certain countries but tend to vary greatly across different farming systems. • Expert opinions may help, but data collection through formal country submission is important. The Code of Conduct for Responsible Fisheries (Code) questionnaires may help motivate this. Countries may be aware of this big issue. • Such data tend to be useful also for farm management (related to economic performance).
Use of wild seed in aquaculture	• Percentage of farmed seed in total seed use in aquaculture	• The impact of use of wild seed on wild stock needs to be evaluated and is dependent on the state of the wild stock.
Use of non-native species in aquaculture	• Ratio of non-native species in total species used in aquaculture • Invasiveness of introduced species used in aquaculture	• Guidelines on the use of non-native species in aquaculture (e.g. Code Article 9.3.3) are available. • GAPI includes an indicator on the use of non-native species with the consideration of the invasiveness of introduced species (calculated as a risk factor). • While it is important to assess trade-offs between the costs and benefits of using introduced species in aquaculture, it is challenging to collect data to assess various trade-offs: o Many studies focus on the negative impacts of introduced species. o A chart on correlation between productivity and introduced species may be helpful but hard to provide concrete advice. o Evaluation of the costs and benefits of using introduced species in aquaculture should be conducted on a case-by-case basis considering the local context. Drawing generalized conclusion at the country level should be avoided.
Diseases as a major problem not only for aquaculture sector per se, but also for impacts on wild species	• Percentage of production loss due to disease • Use of veterinary medicine	• Production loss caused by disease tends to vary across countries and species. Can this indicator be a proxy of impacts of disease on wild species? • Data on the use of veterinary medicine in aquaculture are available in some countries (e.g. Norway) but not worldwide. • Range of monetary loss due to diseases can be a management indicator for disease control. • The private sector is generally reluctant to reveal

Issues	Indicators	Methods
		information on loss from disease.
Efficiency of use of feed inputs	• Ratio of value added to the quantity or value of fish used as feed	• This issue and related indicator were suggested by one of the experts after the workshop, during the preparation of this report. For example, for a country that uses low-value fish as a feed input in aquaculture, this indicator would be needed for the policymaker to achieve the strategic objective of using this resource more efficiently.

69. In addition to the specific issues listed in Table 4, Working Group 3 also provided the following insights on the assessment and monitoring of aquaculture's environmental performance:

- Having an integrated view on multiple environmental impacts is important; SEEA account may be helpful in this regard. All dimensions should be considered together; focusing on a single dimension is unsound.
- The usefulness of environmental indicators is a general concern.
- It is important to distinguish between indicators for management purposes and those for measuring performance.
- It is important to develop specific indicators for different stakeholders.
- It is challenging to develop relevant indicators for integrated systems that include both aquaculture and other farming activities.
- A large proportion of environmental impacts of aquaculture are from the use of aqua feed. Such impacts are usually measured indirectly by nutrition content in feed, feed conversion ratio (FCR), etc.
- The lack of data is a key issue. Countries should be encouraged to submit data on aquaculture's environmental impacts. It is important to prioritize data collection and focus on obtaining data to quantify key indicators.

70. Working Group 3 noted that countries or regions (e.g. Africa) with a relatively young aquaculture sector can learn from the experiences of other places. Some specific examples are summarized as follows:

- Competition tends to occur in the use of land between aquaculture that is often perceived as producing fish as a "cash crop" and agricultural activities that produces grains for staple (e.g. China's experience).
- Environmental externalities tend to occur even within the aquaculture sector (e.g. disease problems for downstream water users in Chile).
- Although it is tempting for countries (especially developing countries) to follow a "food (or economy) first, environment later" strategy in aquaculture development, the experience of countries or regions with more advanced aquaculture (e.g. Norway and Southeast Asia) indicates that the cost of paying inadequate attention to the environmental dimension of aquaculture tends to be large and could have been avoided. Carefully constructed indicators in a project such as WAPI could help incorporate lessons from the past and provide a path forward to mitigate these issues through understanding and measurement.
- Paying adequate attention to the environmental dimension is very important to the public image of aquaculture.

Potential collaborators in assessing and monitoring aquaculture sector performance

71. The three working groups suggested various potential collaborators in the endeavour of assessing and monitoring aquaculture sector performance, including:

- Administrative and statistical agencies of national governments (e.g. department of fisheries, national bureau of statistics, health authorities, and food safety authorities).
- Development/technical agencies of regional organizations (e.g. NEPAD/AU and EUROSTAT/EU).
- International organizations (e.g. World Health Organization and World Bank).
- Fisheries/aquaculture organizations (e.g. Fish InfoNetwork, ANAF, Network of Aquaculture Centres in Asia-Pacific [NACA], and Southeast Asian Fisheries Development Center [SEAFDEC]).
- Development projects/programmes (e.g. Sustainable Aquaculture Research Networks in Sub-Saharan Africa [SARNISSA]).

CLOSING SESSION

72. Mr Nathanael Hishamunda gave a brief summary of the key findings of the workshop.[9] He highlighted two recommendations by the workshop on the follow-up actions of FAO on the WAPI tool:

- Use the comments and suggestions of the Workshop to improve the WAPI tool.
- Select a few countries in Africa, Asia and Latin America to test and improve all aspects of the WAPI tool.

73. In closing, Mr Nathanael Hishamunda thanked the expert participants for their tremendous effort and valuable inputs and expressed FAO's wish to maintain continuing collaboration with them in the enterprise of assessing and monitoring aquaculture sector performance and other areas of aquaculture development.

SUMMARY

74. Effective assessment and monitoring of aquaculture sector performance entails integration of three key elements, i.e. indicators, data and issues. The WAPI tool is intended to facilitate such integration.

Indicators

75. The presentations and brainstorming discussion in this workshop as well as the WAPI tool have illustrated a number of indicators on various dimensions of aquaculture sector performance (see Table 5 for a summary). These indicators reflect only a small part of many efforts in developing indicators on aquaculture.

76. Most of the indicators on aquaculture sector performance require only simple analytical techniques to construct (e.g. calculation of ratios, growth rates). However, simple analyses such as trend analyses and comparisons across countries, species and products could provide powerful information and insightful guidance on aquaculture development.

77. One of the key functions of the WAPI tool is to use standardized templates to facilitate such simple analyses. The standardized templates can replicate often-used tables and graphs for different countries (or country groups), species, products, etc.; they can facilitate easy updating of the tables and graphs with new or revised data.

78. Some indicators may require advanced analytical techniques to construct, e.g. forecasting models discussed in Presentations 12, 13 and 14, multivariate models and/or econometric techniques discussed in Presentations 20 and 27, and the cost–benefit analysis, analytical hierarchy process and social impact assessment discussed in Presentation 25.

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[9] The content of the summary has been incorporated or reflected in the previous text (especially under the section "Feedback from the experts").

79. As recognized and suggested during the workshop, the MS Excel-based WAPI tool may not be a sufficient instrument to conduct advanced analysis but could become a platform to present the results of advanced analyses conducted elsewhere.

80. This is actually the strategy used in the development of Template 68 "Future fish supply–demand gaps (trend)" in the draft WAPI tool. The parameters for projecting future fish demand (e.g. the income elasticity of fish demand) were estimated outside the template by a more sophisticated statistical software (i.e. Stata). Based on these parameters, the template is designed to allow users to evaluate the potential fish supply–demand gaps in the future under different scenarios (e.g. different population growth, income growth, and/or production growth).

81. The results of the fish supply–demand gap analysis cover more than 200 countries and country groups and 6 species groups. It would be cumbersome to publish all the results in a document, whereas the WAPI template gives user the access to the result of any country and species they are interested in. This exemplifies another key function of the WAPI tool, which is to provide a venue for detailed analyses and information that are unable to be accommodated by a document.

TABLE 5

Indicators illustrated by the contents of the workshop

Indicators	**Discussed or presented in:**
Core indictors for assessing and monitoring aquaculture sector performance in a country or region.	• Presentations under Thematic Topic 1. • Summary Template in Section 4.4.1 of the WAPI tool (Appendix 4).
Indicators on aquaculture's contribution to **food and nutrition security.**	• Presentations under Thematic Topic 3. • Brainstorming discussion by Working Group 1 (Table 2). • Templates (5), (6) and (7) in Section 4.4.1 of the WAPI tool (Appendix 4).
Indicators on aquaculture's **socio-economic impacts** (other than its contribution to food and nutrition security).	• Presentations under Thematic Topic 4. • The brainstorming discussion by Working Group 2 (Table 3). • Templates (8) – (12) in Section 4.4.1 of the WAPI tool (Appendix 4).
Indicators on aquaculture's **environmental impacts**.	• Presentations under Thematic Topic 5. • The brainstorming discussion by Working Group 3 (Table 4). • Templates (13) – (25) in Section 4.4.2 of the WAPI tool (Appendix 4).
Performance indicators measuring trade-offs among different dimensions of aquaculture performance.	• Presentations under Thematic Topic 6. • Templates (26) – (37) in Section 4.4.3 of the WAPI tool (Appendix 4).

Data

82. Thematic Topic 2 of the workshop included three presentations (Presentations 6, 7 and 8) on the data and statistics on aquaculture and fisheries provided by FAO and one presentation (Presentation 9) on fish consumption data provided by the private sector. The draft WAPI tool was

developed based on various official and/or publically available data sources. The presentations utilized data and information from various sources.

83. Table 6 summarizes the data sources referred to, explicitly or implicitly, in the contents of the workshop, which include data provided by: (i) international organizations; (ii) regional organizations; (iii) governments; (iv) research institutes; (v) the private sector; and (vi) projects, case studies, technical reports or journal articles.

84. While the lack of reliable data is deemed a main constraint on the assessment and monitoring of aquaculture sector performance, there are actually many data at the national and regional levels not being fully utilized because of the lack of analytical mandate and capacity of data collection agencies. The data collected by various surveys or case studies also tend to be analysed for specific information that may constitute only a small portion of potential information that could be extracted from the data.

85. The ability to present a large amount of data in informative ways makes WAPI templates a user-friendly tool to improve the access and utilization of existing data. With a little extra effort, WAPI indicator templates could add great value to existing data. The larger the dataset, the greater the value added.

Issues

86. In addition to developing relevant indicators and quantifying them with reliable data, another essential part of the assessment and monitoring of aquaculture sector performance is to properly use quantitative indicators to facilitate evidence-based decision-making. Yet, this is often not a straightforward process.[10]

87. For example, the share of aquaculture's value added in GDP is one of the most sought-after indicators, often used to measure the economic performance of aquaculture. However, the use of this indicator in policy decision-making could be elusive. Suppose that the share of aquaculture in GDP declines because of faster expansion in other sectors (e.g. booming oil industry because of newly found reserves), does it mean that aquaculture deserves less public support because of its relatively diminishing economic significance, or does it mean that aquaculture actually needs more public support so as to meet the increasing fish demand expected to be generated by economic growth? Or perhaps the decline is irrelevant information that has no policy implications? Without specific context, the answers to these questions are unclear.

88. The literature (e.g. case studies, technical reports, policy briefs) provides many cases of the use or misuse of quantitative indicators of aquaculture performance, which can be synthesized to systematically demonstrate how the indicators can and should be used to facilitate evidence-based decision-making in aquaculture development.

89. The indicator templates in the draft WAPI tool were developed and structured based on the literature on the assessment and monitoring of aquaculture sector performance. In the future, the templates can be linked to specific publications (e.g. policy briefs) to provide more contextual information. Issue templates can also be developed to facilitate the utilization of the quantitative indicators in the indicator templates.

[10] See Presentation 26 for some discussion in this area.

TABLE 6

Data sources referred to in the contents of the workshop

Data source	Reference
International organization	
FAO aquaculture production database	Presentation 6, 12, 13, 14, 15 and 21; WAPI
FAO capture (fisheries) production database	Presentation 6, 12, 13, 14 and 15; WAPI
FAO total fishery production database	Presentation 11 and 13
FAO fisheries commodities production and trade database	Presentation 7, 12, 13 and 15; WAPI
FAO Food Balance Sheet	Presentation 1, 7, 10, 11, 12, 13 and 14; WAPI
FAO data on seed production from hatchery/nursery	Presentation 6
FAO data on ornamental aquatic animals and plants	Presentation 6
FAO data on water surface and farming systems used in aquaculture	Presentation 6; WAPI
FAO data on employment in aquaculture and capture fishery	Presentation 6, 8 and 15
FAO Globefish	Presentation 19
FAO Code of Conduct for Responsible Fisheries national self-assessment aquaculture questionnaires	Presentation 20
FAOSTAT	WAPI
FAO Statistics Division's data on food security	Presentation 10; WAPI
FAO International Network of Food Data Systems (INFOODS)	WAPI
OECD-FAO Agricultural Outlook	Presentation 13
UN Comtrade	WAPI
UN Population	Presentation 12, 13 and 14; WAPI
International Labour Organization (ILO) databases (LABOURSTA)	Presentation 13; WAPI
IMF World Economic Outlook (WEO)	Presentation 14; WAPI
World Bank World Development Indicators (WDI)	Presentation 13; WAPI
Regional organization	
European Market Observatory for Fisheries and Aquaculture (EUMOFA)	Presentation 1
EUROSTAT	Presentation 1
Government	
China: Aquaculture Production Monitoring System	Presentation 3
China: Aquatic Products Trade Information System	Presentation 3
China: Aquatic Products Wholesale Market Information System	Presentation 3

Data source	**Reference**
China: Fishing Vessel Monitoring and Management System	Presentation 3
China: National Fisheries Statistics System	Presentation 3 and 16; WAPI
Norway: Annual sample profitability surveys	Presentation 4
Norway: Annual statistical surveys of production, employment etc.	Presentation 4
Norway: Data collected from registers of aquaculture operations	Presentation 4
Norway: Statistics Norway	Presentation 4
United States of America: Bureau of Labour Statistics	Presentation 5
United States of America: Census of Aquaculture 1998, 2005 and 2013.	Presentation 5
United States of America: USDA annual surveys of catfish and trout production	Presentation 5
United States of America: USDA national nutrient database	Presentation 11
United States of America: Input-output table for Hawaii	Presentation 16
Research institute	
AMADEUS (a database of comparable financial information for European countries compiled by the European University Institute)	Presentation 1
Global Aquaculture Performance Index (GAPI) developed by SERG at the University of Victoria (Canada)	Presentation 24; WAPI
Private sector	
Data collected by the striped bass industry (United States of America)	Presentation 5
Scanner consumption data provided by A.C. Nielsen (United States of America)	Presentation 9
Scanner consumption data provided by Information Resources Inc. (United States of America)	Presentation 9
Fishmeal and fish oil data (IFFO)	Presentation 12 and 21
Oil World (ISTA Mielke GmbH)	Presentation 13
Project / case study / technical report / journal article	
Economic Performance of the EU Aquaculture Sector (STECF-OWP-12-03)	Presentation 1
European Aquaculture Performance Indicators	Presentation 1
NFFP Assessment of the contribution of fisheries and aquaculture to GDP	Presentation 2
NFFP Assessment of the contribution of fisheries and aquaculture to employment	Presentation 2
The Big Numbers project by FAO, WorldFish Center and World Bank	Presentation 2
The AQUAMAX project by the European Union (Member Organization)	Presentation 10
Expert Consultation on the Risks and Benefits of Fish Consumption	Presentation 11
Dollars, work and food: understanding dependency on the fisheries and aquaculture sector (Scholtens and Badjeck, 2010)	Presentation 16
Status and potential of fisheries and aquaculture in Asia and the Pacific (Lymer *et al*., 2008)	Presentation 16

Data source	Reference
Commercial aquaculture and economic growth, poverty alleviation and food security: assessment framework (Cai *et al*., 2009)	Presentation 16
Improving governance in aquaculture employment: a global assessment (Hishamunda *et al*., forthcoming)	Presentation 17
Social and economic dimensions of carrageenan seaweed farming (Valderrama *et al*., forthcoming)	Presentation 17
FAO/Norad project on seafood value chain	Presentation 18
Climate Change 2007 (an Assessment of the Intergovernmental Panel on Climate Change)	Presentation 22
Reducing water use for animal production through aquaculture (Verdegem *et al*., 2006)	Presentation 23
Development and dissemination of IAA technologies in Malawi (Dey *et al*., 2010)	Presentation 27
Impact of genetically improved carp/tilapia strain in Asia (Dey, 2000; Dey *et al*., 2012)	Presentation 27
AsiaFish model (Dey *et al*., 2008)	Presentation 27
US-catfish model	Presentation 27

APPENDIX 1

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APPENDIX 2

WORKSHOP AGENDA

1st Day: 05 November 2012		
Opening Session		
08:30-08:45	Registration of participants	
08:45-08:50	Adoption of the Agenda	Gullestad, Peter (Chair)
08:50-09:15	Background and introduction of the workshop	Hishamunda, Nathanael
Session 1: Sharing existing experiences, data and information		
Thematic Topic 1: Regional or national experiences in assessing and monitoring aquaculture sector performance		
09:15-09:35	European Aquaculture Performance Indicators (EAPI)	Natale, Fabrizio
09:35-09:55	Assessment of aquaculture in Africa	DeGraaf, Gertjan
09:55-10:15	Aquaculture Industry Information System in China	Yuan, Yongming
10:15-10:30	Coffee break	
10:30-10:50	Aquaculture performance indicators – examples from Norway	Gullestad, Peter
10:50-11:10	United States efforts to assess aquaculture sector performance	Lowther, Alan
Thematic Topic 2: Data and statistics on aquaculture		
11:10-11:25	Data on fish production and natural resources used in aquaculture	Zhou, Xiaowei
11:25-11:40	Data on fish utilization and nutrition of fish	Vannuccini, Stefania
11:40-11:55	Data on employment in aquaculture	Jara Senn, Fernando
11:55-12:10	Data on fish consumption based on store-level scanner data	Dey, Madan
12:10-12:30	Discussion on Topic 1 & 2	
12:30-14:00	Lunch break	
Thematic Topic 3: Aquaculture's contribution to food and nutrition security		
14:00-14:15	Aquaculture's contribution to food and nutrition security	Torstensen, Bente
14:15-14:30	Fish: a healthy alternative; farmed fish: a good choice	Toppe, Jogeir
14:30-14:45	Fish 2030: the WB/IFPRI/FAO/UAPB IMPACT model	Dey, Madan
14:45-15:00	Fish Outlook: the OECD-FAO model	Vannuccini, Stefania
15:00-15:15	Estimating fish demand-supply gaps in the future	Cai, Junning
15:15-15:30	Coffee break	
15:30-15:50	Aquaculture for Food Security, Poverty Alleviation and Nutrition (AFSPAN)	Yamamoto, Koji & Björndal, Trond
15:50-16:10	Discussion on Topic 3	
Thematic Topic 4: Economic performance of aquaculture		
16:10-16:25	Aquaculture's contribution to value addition and GDP	Leung, PingSun
16:25-16:40	Aquaculture's contribution to employment and poverty alleviation	Ridler, Neil
16:40-16:55	Compared value chains between fisheries and aquaculture	Fernández-Polanco, Jose
16:55-17:10	Fish market and trade: a private sector perspective	Estors Carballo, Jose
17:10-17:30	Discussion on Topic 4	

2nd Day: 06 November 2012		
Session 1: Sharing existing experiences, data and information		
Thematic Topic 5: Environmental performance of aquaculture		
08:30-08:50	Assessing and monitoring the environmental impacts of aquaculture	Soto, Doris
08:50-09:00	Environmental and resource constraints in aquaculture: A governance perspective	Björndal, Trond
09:00-09:20	Aquaculture and climate change: objectives and performance criteria	Muir, James
09:20-09:40	Use of water in aquaculture	Ottaviani, Daniela
09:40-10:00	Global Aquaculture Performance Index: a measure of the aquaculture sector's performance	Gee, Jennifer
10:00-10:20	Discussion on Topic 5	
10:20-10:40	Coffee break	
Thematic Topic 6: Measuring the net impact of aquaculture		
10:40-11:00	Different approaches on measuring the net impact of aquaculture	Ridler, Neil
11:00-11:20	Assessing tradeoffs among various impacts of aquaculture and measuring the net impact	Hambrey, John
11:20-11:40	Impact of aquaculture under various policy scenarios in both developed and developing countries	Dey, Madan
11:40-12:00	Application of the System of Environmental-Economic Accounts (SEEA) in aquaculture	Ottaviani, Daniela
12:00-12:30	Discussion on Topic 6	
12:30-14:00	Lunch break	
Session 2: World Aquaculture Performance Indicators (WAPI): A User-friendly Tool		
14:00-15:00	World Aquaculture Performance Indicators (WAPI): A User-friendly tool	Cai, Junning
15:00-15:15	Forming 3 working groups (Food and nutrition security, Economic performance, and Environment performance)	Hishamunda, Nathanael
15:15-15:30	Coffee break	
15:30-17:30	Discussion, comments and suggestions on the draft WAPI tool	

3rd Day: 07 November 2012	
Session 3: Assessing and monitoring of aquaculture sector performance: practical and integrated ways	
08:30-10:15	Working group discussions
10:15-10:30	Coffee break
10:30-12:30	Working group discussions (continued)
12:30-13:30	Lunch break
13:30-15:30	Plenary discussion
Closing Session	
15:30-15:50	Summary by Nathanael Hishamunda

APPENDIX 3

SUMMARY OF THE THEMATIC PRESENTATIONS

Presentation 1: European Aquaculture Performance Indicators (by Fabrizio Natale)

The European Aquaculture Performance Indicators (EAPI) (developed by the Joint Research Centre [JRC]) include quantitative indicators for measuring the performance of the aquaculture sector in the European Union with the aim to assist national authorities in preparing aquaculture strategic plans and monitoring their implementation. EAPI include quantitative indicators on the economic, social, environment and governance aspects of aquaculture sector performance. The major indicators in EAPI are summarized as follows[1]:

- Economic indicators: (1) growth rate of aquaculture production over recent years; (2) ratio of gross value added (GVA) from aquaculture to that from agriculture; (3) profitability of aquaculture enterprises (ratio between earnings and revenue); (4) trade balance (proportion of aquaculture products in the total export of fisheries products); (5) species diversification (the extent to which different species contribute to aquaculture production), and (6) labour productivity (ratio between GVA from aquaculture and the number of persons employed in aquaculture).
- Social indicators: (7) employment (ratio between number of persons employed in aquaculture and total employment), and (8) per capita apparent consumption of fisheries products.
- Environmental indicators: (9) ratio between total quantity of fishmeal used and total aquaculture production; (10) ratio between total quantity of fish oil used and total aquaculture production; (11) ratio between total effluents of nitrogen and total aquaculture production, and (12) ratio between total effluents of phosphorus and total production.
- Governance indicators: (13) number of new licenses and authorized production volume; (14) size of allocated zones for aquaculture, and (15) subsidies allocated/paid for the sector in relation to the value of the national aquaculture production.

Presentation 2: Assessment of aquaculture in Africa (by Gertjan De Graaf)

The presentation emphasized that indicators should be selected based on the objectives; data collection should be kept simple with consideration of financial and human resources; and data may be found outside the fisheries administration (e.g. agriculture household and population census, geographical information systems).

The presentation highlighted some key indicators on aquaculture performance, including: (1) aquaculture production (by species and value), (2) the contribution of aquaculture to food balance sheets, (3) aquaculture's contribution to food accessibility (e.g. market chain information), (4) aquaculture's contribution to gross domestic product (GDP), (5) aquaculture exports (both quantity and value), (6) aquaculture employment (by gender), and (7) investment in aquaculture.

The presentation also shared some preliminary results of the contribution of fisheries and aquaculture to GDP estimated by a study under the NEPAD-FAO Fish Programme (NFFP).

Presentation 3: Aquaculture industry information system in China (by Yongming Yuan)

The presentation indicated that the national aquaculture information system in China includes several components:

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[1] More details can be found in the JRC Technical Report on "An approach towards European Aquaculture Performance Indicators: Indicators for sustainable aquaculture in the European Union". Available at http://publications.jrc.ec.europa.eu/repository/bitstream/111111111/27600/1/jrc_g04_fishreg_eapi%20final.pdf

- National fisheries statistics system, which is supported by multiple government agencies (e.g. Bureau of Fisheries, Ministry of Agriculture, and National Bureau of Statistics) as well as organizations in the private sector (e.g. China Society of Fisheries).
- Aquaculture production monitoring system, which included 747 monitoring stations in 200 sampling counties of 16 selected provinces, covered 39 freshwater species and 39 marine species, and involved 5 000 farmers in 2011.
- Fishing vessel monitoring and management system, which included 251 monitoring vessels and more than 1 000 survey vessels in 2011.
- Aquatic products wholesale market information system, which covered 80 key wholesale markets countrywide, 253 aquatic products or species, and 617 product specifications in 2011.
- Aquatic products trade information system, which monitors China's exports and imports of aquatic products and is supported by Bureau of Fishery, Ministry of Agriculture, and the Information Center of China Customs.

The presentation also introduced China's Agriculture Industrial Information System (AIIS), which covers five major aquaculture species in the country: carps, tilapias, flatfishes, shrimps and molluscs. Under the AIIS, an "early warning system on the tilapia industry" is being constructed to assess and monitor the status and trends of the development of China's tilapia industry. The early warning system is intended to use economics, management science and information technology to conduct quantitative and qualitative analysis to explain the status of the industry, forecast its future development trend, and identify warning signals (e.g. market glut).

In conclusion, the presentation emphasizes that information systems play vital roles in facilitating sustainable aquaculture development in China; and the effectiveness of information systems depends on the availability of timely and reliable information, which requires collaboration among all concerned stakeholders.

Presentation 4: Aquaculture performance indicators – Norwegian examples (by Peter Gullestad)

The presentation highlighted two different data sources for creating indicators: (1) data provided by registered aquaculture farmers as an integral part of sector management (e.g. farm sites, biomass, fish health, pollution, escapees, export); and (2) data collected for statistical purpose (e.g. annual statistics surveys of production and employment in aquaculture, annual sampling surveys of the profitability of aquaculture enterprises).

The presentation illustrated some key indicators of the status and trends of aquaculture development in Norway:

- The number of licences for salmon and trout farming has increased since 2000, whereas that for shellfish or other marine species has declined.
- Aquaculture production quantity doubled between 2000 and 2010 because of the expansion of salmon and trout farming. Aquaculture production exceeded one million tonnes in 2010, which was less than capture fisheries production (about 2.7 million tonnes) but more than the production of meat and poultry (0.3 million tonnes).
- Aquaculture production value has also been on an upward trend. However, aquaculture production value declined in 2001, 2007, 2008 and 2011 despite increases in the production quantity in the same years because of price declines.
- Labour productivity has increased from less than 200 tonnes/worker to more than 300 tonnes/worker since the mid-2000s.
- The ratio of female workers is higher for seasonal jobs than permanent jobs and for juvenile production than grow-out production.
- The production cost per kilo of salmon and trout production declined from more than NOK70/kg in 1986 to NOK20/kg in 2010.

- The profit margin of salmon and trout production has been fluctuating over approximately five-year cycles. High profit margins (about 30 percent) occurred in 2000, 2005–06 and 2010.
- The export value of aquaculture products increased from NOK10 billion in the mid-1990s to more than NOK30 billion in 2010; whereas that of capture fisheries products remained stable at about NOK20 billion.

The presentation also introduced the Strategy for an Environmentally Sustainable Norwegian Aquaculture Industry – 2009.[2] The strategy focuses on five main areas of aquaculture's environmental impacts (i.e. genetic interaction, pollution, diseases, spatial planning, and feed and feed resources) and discusses challenges, status and government's existing and potential measures for these five areas.

The presentation noted that, with the benefit of hindsight, many environmental problems encountered by Norway on the course of its aquaculture development could have been avoided or alleviated had industry and government at an earlier stage paid more attention to the environmental challenges facing a rapidly growing industry.

The presentation highlighted several major indicators of the environmental performance of Norway's aquaculture sector, including:

- The number of escapees (Atlantic salmon and rainbow trout) was about 300 000 fish in 2010, which was a little lower than the level in 2000, even though production doubled during the period.
- The number of sea lice per fish fluctuated with the season from less than one in May–July to three in October–November.
- The use of antibiotics in aquaculture has declined from more than 30 tonnes in 1990 to less than 5 tonnes since the 2000s, even though the aquaculture production has increased many times over during the same period.
- The percentage loss in salmon production has remained stable around the level of 20 percent since 2000. Almost 80 percent of the loss was caused by the death of fish during the farming process.
- The environmental status of aquaculture sites. In 2011, 90 percent of monitored sites were classified as having a good or a very good environmental status, whereas 8 percent were classified as not so good and 2 percent as having a bad environmental status.

Presentation 5: Assessing the aquaculture sector in the United States of America (by Alan Lowther)

The presentation noted that aquaculture in the United States of America is a small sector with only a few species being cultivated (catfish, Atlantic salmon, crawfish, oysters, clams, etc.). Relatively high labour costs and conflicts over the use of natural resources (mainly land and water) have been major constraints over aquaculture development in the country, but there are opportunities in niche markets for aquaculture products.

The presentation noted that notwithstanding a relatively small aquaculture sector, the United States of America is a leader in aquaculture research, especially in the area of aquafeed and farming technology.

The presentation noted that aquaculture is subject to local regulations in the 50 states of the country; the National Oceanic and Atmospheric Administration (NOAA) only has jurisdiction over aquaculture in the exclusive economic zone (EEZ).

The presentation highlighted several indicators for assessing and monitoring aquaculture sector performance in the United States of America:

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[2] Available at:
www.regjeringen.no/upload/FKD/Vedlegg/Diverse/2009/strategy%20for%20an%20sustainable%20aquaculture.pdf

- Volume and value of aquaculture production are the basic indicators of aquaculture performance. There is no comprehensive national data collection programme on aquaculture production. National aquaculture production statistics are assembled from various sources, such as annual surveys of catfish and trout production by the United States Department of Agriculture (USDA), data collected by some industries (e.g. striped bass), etc. A census on aquaculture is expected in 2013. The long-term goal is to develop a regular, national data collection plan.
- Seafood trade deficit, percentage of imported seafood in total United States seafood consumption, and percentage of aquaculture in total United States seafood consumption are indicators of the economic performance of the country's aquaculture sector in terms of reducing its dependence on imported seafood. The country's seafood trade deficit was on an upward trend in the 2000s and exceeded USD10 billion in 2010 and 2011.
- Employment is another indicator of aquaculture's economic performance. The employment in country's aquaculture sector has been stable at about 6 000 jobs.
- Percentage of fishmeal and fish oil in aqua feed is an indicator of the sector's sustainability in terms of feed efficiency.
- The number of steps or agencies involved and the length of time needed to obtain a permit for conducting aquaculture are indicators measuring the governance performance in terms of the efficiency of the regulatory process for new farmers.
- Consumer attitudes based on accurate information are an indicator measuring the performance in better informing the public about aquaculture in the United States of America.
- The number of accepted or rejected applications for new aquaculture ventures is an indicator measuring the competition between aquaculture and other land and water uses.
- Number of escapes from marine fish farms and number of disease outbreaks in marine fish farms are two indicators of aquaculture's environmental performance in terms of minimizing or eliminating the environmental damages of aquaculture.

Presentation 6: FAO data and statistics on aquaculture production and resource use (by Xiaowei Zhou)

The presentation introduced the scope of FAO statistics on aquaculture and fisheries, which covers capture fisheries, aquaculture, commodities and trade, fishing vessels, employment, and food balance sheet (including fish consumption).

The presentation noted that the quantity and value of aquaculture grow-out production have been regularly collected and disseminated by FAO. The quantity is measured in live weight. The value is measured by the farmgate price (i.e. the value per kilogram at first sale) in national currency. The data are sorted by species, farming environments (freshwater, brackish and marine), and culture methods (ponds, cages, etc.). The data cover food fish (i.e. aquatic animals for consumption), aquatic plants (algae), and non-food products (e.g. pearls).

The presentation noted that data on aquaculture surface area and facilities have been collected but not disseminated as official statistics by FAO because of issues such as low percentage of reporting countries, poor data quality, unclear differentiation between utilized and non-utilized aquaculture area or facilities, and inconsistent categorization of aquaculture area or facilities.

The presentation noted that the number of fingerlings produced from hatcheries has been collected but not disseminated as official statistics by FAO because of issues such as low percentage of reporting countries, inconsistency in the measurement of the quantity of fingerlings (number vs weight), unclear age of fingerlings, and inclusion of wild-caught seeds.

The presentation noted that FAO also collects the number and value of ornamental aquatic animals and plants from member countries of the Southeast Asian Fisheries Development Centre / Association of Southeast Asian Nations (SEAFDEC/ASEAN). The data have not been disseminated as official statistics of FAO.

The presentation highlighted several global, salient issues that affect the availability and quality of FAO aquaculture statistics, which include: (1) less importance given to aquaculture statistics by member countries; (2) the lack of monitoring of aquaculture surface area and facilities; (3) the lack of monitoring of the price or value of aquaculture products; (4) misreporting retail or export price as farmgate price; (5) cultured species highly aggregated; and (6) aquaculture vulnerability (e.g. production or economic losses) not measured.

Presentation 7: FAO data and statistics on utilization, trade and consumption (by Stefania Vannuccini)

The presentation introduced the fisheries commodities production and trade dataset disseminated by FAO, which covers 212 countries, territories or land areas and more than 1 000 commodities or items. The dataset includes statistics on the production, import, export and re-export of fish and fisheries commodities.

The presentation also reported that, heretofore, there has been no breakdown between farmed and wild products in FAO's fishery trade statistics. The classification used internationally as a basis for the collection of customs duties and international trade statistics (the Harmonized Commodity Description and Coding System, commonly referred to as the Harmonized System [HS]) does not distinguish between fish and fishery products of wild and farmed origin. In addition, only a few countries have introduced such a breakdown for selected species in their national classifications based on HS. It is therefore not possible to obtain a consistent worldwide figure.

The presentation introduced the Food Balance Sheets (FBS) for fish and fisheries products as calculated by FAO and the methodology followed. It was noted that the FBS are useful to analyse the status and trends of the seafood sector in a country and provide information for policy analysis and decision-making regarding food security. For example, FBS provide key information for estimating the contribution of fish and fishery products to food and nutrition security and an important element in the projections of fish demand.

The presentation pointed out that the main problems encountered in the calculation of the FBS include: (1) reliability of basic data used to prepare the FBS; (2) accuracy of factors used to convert product weight to live weight; and (3) difficulty in obtaining data and information on post-harvest losses, species composition, processed commodities, stocks of fisheries commodities and subsistence fisheries and aquaculture.

The presentation also reported that possible areas of improvements for FBS include: (1) the breakdown of the present group composed of freshwater and diadromous fish into two separate groups (one for freshwater and another for diadromous species); (2) the breakdown of the present group of pelagic fish into two groups ("tunas and tuna-like fishes" and "other (small) pelagic"; (3) the revision of the nutritional factors; and (4) the inclusion of aquatic plants.

The presentation also covered several other topics, including: (1) the revision of the HS of the World Customs Organization (WCO); (2) the revision of the Central Product Classification (CPC) of the United Nations Statistics Division; (3) integration of fishery and aquaculture into other surveys (e.g. agriculture, household, rural and national census); and (4) the role of the Coordinating Working Party (CWP) on Fishery Statistics, which is to provide a mechanism to coordinate fishery statistical programmes of regional fishery bodies and other intergovernmental organizations.

Presentation 8: FAO data and statistics on employment in aquaculture (by Fernando Jara)

The presentation introduced the history of FAO's efforts in providing statistics on employment in fisheries and aquaculture and noted that FAO has been collecting employment data in fisheries and/or aquaculture via questionnaires sent annually to Members. Such questionnaires have evolved, regarding the degree of detail of the data requested, from the initial simple ones in the 1950s to the much more detailed ones in the 2000s.

The presentation noted that the latest questionnaires request Members to report the "number of fishermen and fish farmers – commercial and subsistence" in aquaculture, inland fishing, marine coastal fishing, deep-sea fishing, marine fishing not elsewhere included, subsistence fishing or fish farming activities, and unspecified fishing or fishing farming activities. The working status (i.e. full-time, part-time, occasional or unspecified) and gender (male, female or unspecified) of the jobs also need to be specified.

The presentation noted that FAO's fisheries and employment statistics were last published as the "Numbers of Fishers 1970–1997" as FAO Fisheries Circular No. 929 Rev. 2.[3] The FAO employment database is currently in preparation for electronic release.

The presentation noted that the proportion of countries reporting employment in aquaculture relative to those reporting aquaculture production increased from less than 10 percent in the early 1980s to about 40 percent in the late 2000s. In 2010, about 180 Members reported aquaculture production to FAO; more than 120 Members reported employment in the fisheries and aquaculture sector; almost 80 Members reported employment in aquaculture separate from employment in capture fisheries; and almost 40 Members reported female employment in aquaculture.

The presentation noted that, based on the employment data reported by Members, FAO has been publishing the estimated number of world fishers and fish farmers by region in *The State of World Fisheries and Aquaculture* (SOFIA). The latest estimation (published in SOFIA 2012) indicates that the number of world fish farmers exceeded 16 million in 2010.

In addition to inadequate reporting by Members, the presentation highlighted some other constraints on FAO's capability to provide detailed fisheries/aquaculture employment statistics, such as employment in aquaculture and capture fisheries being reported as an aggregate, the lack of disaggregation by gender, and the lack of official confirmation to validate employment data obtained from private industry organizations (e.g. farmers associations).

Presentation 9: Data on fish consumption based on store-level scanner data (by Madan Dey)

The presentation provided a brief overview of store-level consumption data collected by market research firms for understanding current market conditions. Two major firms collecting such data are Information Resource Inc. and A.C. Nielsen; both of which are market research companies based in the United States of America.

Two types of data (i.e. household-based scanner data and store scanner data) are collected by scanning the barcodes (e.g. universal product codes [UPCs]) of food products sold by participating groceries and supermarkets.

The scanner data provide information on the descriptive characteristics of a product (city, product form, packaging size, UPC barcode, brand, etc.) as well as sales information (sales value, unit volume, unit size, average unit price, sales value with promotion, sales unit value, dollar share, etc.). The presentation noted that such timely yet proprietary data are not readily available to the public and usually need to be purchased.

The presentation illustrated that store-level scanner data can be used to calculate quantitative indicators such as: (1) the market shares of different seafood categories; (2) market share of different store brands; (3) the accumulated market share of top five or top ten brands; (4) the number of brands, product forms, product styles or packing size for a seafood product; (5) the share of a species in a

[3] FAO. 1999. *Number of fishers 1970-97*. FAO Fisheries Circular No. 929, Rev. 2. Rome.

specific type of seafood products (e.g. unbreaded); and (6) monthly growth rates of the value, quantity or price of a seafood product.

The presentation also presented some results from demand analysis based on store-level scanner data. The results indicate that in most parts of the United States of America, the own-price elasticity of consumer's demand is about –1.00 for catfish and about –1.25 for tilapia and salmon; while the expenditure elasticity is about 1.2 for catfish and tilapia and slightly lower than 1 for salmon.

Presentation 10: Aquaculture's contribution to food and nutrition security (by Bente Torstensen)

The presentation highlighted the contribution of fish to nutrition security by providing high-quality animal proteins, fatty acids, vitamins, minerals and other important micronutrients and noted that with obesity and related diseases (e.g. Type-II diabetes) becoming more prevalent, the health benefits of fish have been increasingly recognized in developed countries.

Based on FAO statistics, the presentation showed that fish contributed to about 6 percent of world total protein intake and 16 percent of animal protein intake. The share of fish in the total protein intake is lower in relatively developed regions (e.g. Europe and Northern America), which implies that generally speaking, fish is a more important protein source in less developed regions than in more developed regions.

The presentation noted that while herbivorous or omnivorous freshwater fish (carps, tilapias, catfishes, etc.) contributed to most of world aquaculture production, seafood from the marine environment provides a unique mix of nutrients (protein, marine omega-3 fatty acids such as EPA and DHA, vitamin D, vitamin A, vitamin B12, selenium, iodine, etc.).

The presentation noted that the increasingly popular practice of using plant protein and lipid sources to replace fishmeal and fish oil as feed ingredients for marine aquaculture would tend to affect the nutrition value of marine seafood (e.g. reducing vitamin D, selenium and marine omega-3). Aquaculture development in the future should address this issue.

Presentation 11: Fish – a healthy alternative; farmed fish – a good choice (by Jogeir Toppe)

The presentation highlighted that fish is a complete source of nutrients contributing to 17 percent of animal protein intake on average worldwide and more than 50 percent in many of the poorest countries. Fish is an important source of omega-3 fatty acids (DHA and EPA), which are vital to brain development and protection against coronary heart diseases. Fish is also rich in minerals and micronutrients, but these nutrients are concentrated in parts (e.g. head and bone) that are often discarded as waste.

Based on the Report of the Joint FAO/WHO Expert Consultation on the Risks and Benefits of Fish Consumption,[4] the presentation illustrated the trade-off between omega-3 content and mercury content in different seafood products. Generally speaking:

- Seafood products that contain relatively high omega-3 but relatively low mercury include small pelagic marine fishes (anchovy, herring, sardine and mackerel), salmon and rainbow trout, crab meat, and cod liver.
- Seafood products that contain low omega-3 but high mercury include large pelagic marine fishes (e.g. marline, bigeye tuna and orange roughy).
- Pacific bluefin tuna has both relatively high omega-3 and relatively high mercury.

[4] FAO/WHO. 2011. *Report of the Joint FAO/WHO Expert Consultation on the Risks and Benefits of Fish Consumption, Rome, 25–29 January 2010*. Rome, FAO; Geneva, WHO. 50 pp. (also available at www.fao.org/docrep/014/ba0136e/ba0136e00.pdf).

- Seafood products with both relatively low omega-3 and relatively low mercury include demersal marine fish (e.g. cod, haddock, sole), freshwater species (e.g. catfishes and tilapias), and molluscs (e.g. clams, oysters, scallops).

The presentation compared the nutrition value of farmed fish with wild fish and other farmed animals and noted that farmed fish could potentially be a healthy alternative to wild fish because of controlled inputs and more constant nutrient composition.

Based on data from the USDA, the presentation showed that: (1) farmed salmon could have a higher omega-3 content than wild salmon; (2) farmed freshwater species (carp and tilapia) tend to have a much lower omega-3 content than wild salmon but a much higher content than chicken and beef; and (3) these animal products have similar protein contents.

The presentation showed that small pelagic marine fishes (sardines, anchovies, mackerel and herring) are the main contributor of omega-3 to the world's population.

The presentation noted that although carp has a relatively low omega-3 content compared with marine species, it is nevertheless the third greatest omega-3 contributor (next to sardines and anchovies) thanks to the large volume of total carp production in the world.

Presentation 12: Fish to 2030 – a WB/IFPRI/FAO/UAPB research effort (by Madan Dey)

The presentation introduced the "Fish to 2030" model, which is a joint project of the International Food Policy Research Institute (IFPRI), the World Bank (WB), the University of Arkansas at Pine Bluff (UAPB), and FAO to forecast fish production and utilization in 2030.

The "Fish to 2030" model uses IFPRI's Impact Model as the baseline model and extends it to include several subsectors of aquaculture and fisheries. The production/supply side of the model includes 16 food fish categories;[5] whereas its consumption/demand side includes 10 food fish categories.[6] The mismatches of fish categories between the supply and demand sides are due to the fact that available data on fish production (from FAO FishStat) are more disaggregated than those on fish consumption (from the Food Balance Sheet in FAOSTAT).

Compared to IFPRI's "Fish to 2020" model[7] developed in early 2000s, the "Fish to 2030" model includes more disaggregated fish species that distinguish important species and differentiate fed and non-fed species.

The "Fish to 2030" model also improves the modelling of the supply of fishmeal and fish oil by completely endogenizing the use of low-value species for production of fishmeal and fish oil. In addition, the non-fish side of the model also has numerous improvements compared with the "Fish to 2020" model.

Some important assumptions of the "Fish to 2030" model include: (1) population growth assumed to follow UN projections (medium variant); (2) per capita GDP growth (as a proxy of income growth) assumed to follow WB projections; (3) capture fisheries production assumed to be exogenous; (4) rates of technological change specified based on expert assessment of the growth potential; and (5) changes in the feeding efficiency of fishmeal and fish oil assumed to be in line with observed changes.

[5] On the production side, the food fish categories are: shrimp and prawns, crustaceans excluding shrimp and prawns, molluscs and other invertebrates, salmon, demersal marine fishes, tunas, cobia and swordfish, eels and sturgeon, tilapias, *Pangasius*, major carps, mullet, silver carp and grass carp, other fresh and diadromous finfishes, pelagic marine fishes excluding tunas, and other marine animals.

[6] On the consumption/demand side, the food fish categories are: shrimp and prawns, crustaceans excluding shrimps and prawns, molluscs and other invertebrates, salmon, freshwater and diadromous finfishes, demersal marine fishes, tunas, pelagic marine fishes excluding tunas, and other marine animals.

[7] See details at www.ifpri.org/publication/fish-2020

The presentation illustrated some preliminary results of the model on fish production and consumption in 2030.

Presentation 13: Fish model and projections in OECD–FAO Agricultural Outlook (by Stefania Vannuccini)

The presentation provided a brief introduction about the OECD–FAO's Aglink-CO.SI.MO. modelling system, one of the most comprehensive partial equilibrium models for the analysis of international agriculture and food markets. The model is used to generate medium-term projections (a ten-year horizon) on annual supply, demand and prices for selected agricultural commodities. The model is one of the tools used in the generation of the baseline projections underlying the OECD–FAO Agricultural Outlook annual publication presenting projections and related market analysis for some 15 agricultural products.

The presentation also gave a more detailed introduction of the fish model recently developed by FAO, with the collaboration and agreement of the Organisation for Economic Co-operation and Development (OECD) and FAO Secretariats for Aglink–CO.SI.MO. The fish model is still a satellite component of the Aglink–CO.SI.MO. model, to which it is linked but not integrated into. The fish model has been built following the same general principles of Aglink–CO.SI.MO in order to facilitate its eventual integration. It includes more than 1 100 equations for modelling fish production, utilization and trade in 46 countries or regions.

On the supply side, the fish model includes two types of supply functions (i.e. capture fisheries and aquaculture). The capture fisheries production is treated as exogenous for most countries/regions, while it is assumed as endogenous only for the countries affected by El Niño phenomenon or responding to price. For aquaculture, 99 percent of the total world is endogenous and responding to the price of output and the price of feed. The aquaculture production functions take into account differences of main species in terms of production lag, amount, type and efficiency (i.e. FCR) of feed used in farming, and the price elasticity of supply. The supplies of fishmeal and fish oil consider not only the capture and utilization of fish for reduction but also fish residues.

On the demand side, the fish model considers the utilization of fish as food, for production of fishmeal and fish oil, and for other non-food purposes. For a country or region, the demand for food fish is determined by its income and the prices of fish and other food products; the demands for fishmeal and fish oil are determined by aquaculture production and the relative prices between fishmeal/fish oil and oilseed meal/oil; and the demand for other non-food purposes is treated as exogenous.

Fishery exports (or imports) of one country or region are determined by the ratio between its domestic fish price and the price of its fish export (or import). The export price is assumed to be the fish price in the world market (i.e. the world fish price); and the import price is equal to the world price plus transport cost and tariff.

The presentation illustrated some key projections for 2021 based on the fish model and noted that the complete results were reported in the fish chapter of the OECD–FAO Agricultural Outlook 2012–2021, disseminated in June 2012. The fish projections were based on several specific assumptions, including: (1) El Niño affecting capture fisheries production in South America in 2015 and 2020; (2) full utilization of most fish quotas; (3) slowing productivity growth in aquaculture; and (4) innovations in feed technologies will not be able to prevent the increase in the price of fishmeal (or fish oil) relative to that of oilseed meal (or oil). Based on these assumptions, the fish model produced the following projections:

- Capture fisheries production will remain stable at about 90 million tonnes in the next decade. Aquaculture production will continue to grow, but not as fast as in the previous decade. The production of fishmeal will increase slightly, with most of the growth coming from the processing of fish residues.

- World per capita fish consumption will increase slightly from about 18.5 kg/capita in 2009−2011 to about 19.6 kg/capita in 2021. Per capita fish consumption will increase in most regions except Africa, where it will decline slightly because of strong population growth. The contribution of aquaculture to food fish consumption will continue rising, with aquaculture being expected to surpass capture fisheries in 2018.
- World fish trade will continue to grow, but at a lower rate compared with the past.
- World prices for capture, aquaculture and traded fish products will continue to increase. The growth rate of cultured fish price is expected to be higher than that of captured fish. The prices of fishmeal and fish oil are also expected to continue rising.

At the end, the presentation highlighted the way forward for the fish model, which includes: (1) ameliorating the fish model; (2) incorporating fish into the feed demand system of the Aglink–CO.SI.MO. model; (3) further and better collaboration between FAO/FI and FAO/ES and OECD also through the OECD Committee for Fisheries; (4) to produce new fish projection covering the years 2013–2022 and a resulting fish chapter to be included in the 2013 issue of the OECD–FAO Agricultural Outlook publication; and ultimately (5) merging the fish model into the Aglink–CO.SI.MO. model.

Presentation 14: Estimating future fish supply–demand gaps (by Junning Cai)

The presentation discussed a partial equilibrium (PE) model developed by FAO/FI for examining future fish demand and supply. While general equilibrium (GE) models (e.g. IFPRI's "Fish to 2020" model, the OECD–FAO fish model, and the WB/IFPRI/FAO/UAPB's "Fish to 2030" model) examine fish demand and supply as well as their interactions through the price mechanism, the FAO/FI model focuses mainly on the demand side and treats prices as exogenous in order to examine potential supply–demand gaps in the future.

In essence, while the GE models try to forecast what fish production, consumption, trade and price would most likely be in the future under certain situations, the PE model is intended to examine what fish production should be in the future in order to have enough fish to feed the growing and more wealthy population.

The FAO/FI PE model is a more heuristic and normative approach that allows more flexibility in providing policy guidance. For example, in addition to supply–demand gaps, the results from the FAO/FI model could be used to calculate the growth rates of countries' aquaculture production needed to satisfy future fish demand growth driven by population and economic growth.

While the much simpler FAO/FI PE model provides less complete projections, it can nevertheless accommodate more details (e.g. more disaggregated countries and species) than sophisticated GE models.

The presentation used some examples to highlight the importance of details. According to the estimation results of the FAO/FI PE model, the world as a whole would have enough fish to feed the growing population, as long as countries' aquaculture production follows recent trends. However, looking into detail would indicate that the supplies of marine finfish and cephalopods would not be sufficient; and for most countries or territories (155 out of 210), the extra supply from their own aquaculture growth would not be enough to cover the extra demand from their own population growth.

Unlike GE models that often "borrow" elasticity parameters from the literature, the FAO/FI PE model uses econometric techniques (i.e. a panel model) to systematically estimate countries' elasticities of fish demand based on their historical patterns of fish consumption and income growth. The elasticity parameters so estimated can be used in GE modelling to improve consistency and reliability.

The presentation suggested that the PE approach should become an integrated part of GE modelling so as to help users better understand the rationales of the projection results of GE models.

Presentation 15: AFSPAN: an EU project on the socio-economic impacts of aquaculture (by Trond Björndal and Koji Yamamoto)

AFSPAN is an EU project intended to better understand the current status of the aquaculture's contribution to food and nutrition security and poverty alleviation. In particular, the project will: (1) review the current knowledge on the contribution; (2) develop methodologies for better assessment of the contribution; (3) disseminate the knowledge gained among countries, governments and civil societies; and (4) elaborate strategies for improving the contribution.

The project involves partners in 11 countries, including Kenya, Uganda and Zambia in Africa, Bangladesh, China, India, the Philippines and Viet Nam in Asia, and Brazil, Chile and Nicaragua in Latin America.

The project includes nine work packages (WP) led by FAO and other institutions: (1) WP1-Project management (led by FAO); (2) WP2-Assessment methodologies (led by Institute of Development Studies); (3) WP3-Review and assessment of national and international cooperation (led by FAO); (4) WP4-Sustainable aquaculture systems and institutions (led by WorldFish Center); (5) WP5-Social and cultural factors affecting aquaculture (led by WorldFish Center); (6) WP6-Nutrition education in aquaculture (led by University of Copenhagen); (7) WP7-Trade and markets (led by University of Portsmouth); (8) WP8-Synthesis, policy guidance and coordinating arrangements (led by FAO); and (9) WP9-Communication and dissemination (led by Network of Aquaculture Centres in Asia-Pacific [NACA]).

The main objectives of WP2 are to: (1) produce a comprehensive state-of-the-art methodology to be used by the project partners for assessing the contribution of aquaculture to alleviating poverty, improving food and nutrition security in low-income food-deficit countries (LIFDCs); (2) develop an integrated framework that builds and expands on this knowledge; and (3) quantify in a simple and rigorous way the contribution of aquaculture to food security and poverty alleviation in LIFDCs.

The presentation provided more detailed discussion on WP7, which includes two components. One is to provide an overview of seafood trade with focus on aquaculture and developing countries. Some key features of seafood trade include: (1) global seafood trade has grown faster than seafood production in the past three decades; (2) the seafood market has become global with a large proportion of seafood production traded internationally; and (3) developing countries generally export relatively expensive seafood while they import relatively cheaper seafood.

The other component of WP7 is to conduct case studies on how market access affects the contribution of aquaculture to specific communities. The case studies would cover different types of farmers (subsistence, producers for local markets and producers for international markets) and try to find out how the situations of these farmers differ from five or ten years earlier.

The presentation noted that at the macro level, key indicators for assessing and monitoring aquaculture sector performance include: (1) "background information on the society"; (2) "socio-demographic variables including other employment opportunities"; (3) "economic effects from support activities"; (4) "information on institutions"; and (5) "general information on aquaculture and other important industries".

The presentation noted that at the micro level, surveys and/or interviews would be conducted to gather information on: (1) the production characteristics and market behaviours of farmers or companies; (2) the characteristics of aquaculture employment; (3) the characteristics (e.g. education level) of aquaculture workers; and (4) the perceptions of stakeholders on aquaculture's impacts on the community.

Presentation 16: Aquaculture's contribution to value addition and GDP (by PingSun Leung)

The presentation raised the issue of the lack of information on aquaculture's contribution to GDP through farming activities per se as well as backward (upstream) and forward (downstream) linkages. As a relatively small sector, aquaculture is usually lumped together with capture fisheries in national accounts or input–output models. The value of aquaculture production is often used as a proxy to measure aquaculture's and/or fisheries' contribution to GDP.

The presentation noted some efforts on estimating aquaculture's contribution to GDP: (1) FAO Fisheries and Aquaculture Technical Paper No. 512[8] discusses a method for estimating aquaculture's contribution to GDP; (2) China Fishery Statistical Yearbooks publish detailed statistics on value added in China's fisheries and aquaculture sectors and related subsectors; and (3) the World Aquaculture Performance Indicators (WAPI) tool (developed by FAO/FI) includes sample templates on aquaculture's contribution to GDP.

The presentation noted the confusion on the use of "multiplier effects" to measure an industry's contribution to GDP and clarified the concept of *ex post* measurement versus *ex ante* impact simulation.

The presentation discussed the merits and pitfalls of three common procedures of measuring the contribution of an industry to GDP based on input–output models, including final demand-based, output-based and hypothetical extraction methods, and noted that none of the three methods is ideal for measuring the contribution from an *ex post* perspective.

The presentation highlighted several accounting frameworks developed by the UN, including: (1) *A system of economic accounts for food and agriculture*,[9] published by FAO in 1996; (2) *Integrated environmental and economic accounting for fisheries*;[10] and (3) *System of environmental-economic accounting: central framework*,[11] prepared by FAO and partners in 2012.

The presentation noted that regular compilation of environmental-economic accounts in countries as part of a programme of official statistics will: (1) foster international statistical comparability; (2) provide policy relevant information at national, regional and international levels; and (3) improve the quality of the resulting statistics and understanding of the measurement concepts.

The presentation used examples to highlight the System of Environmental and Economic Accounting (SEEA) (Central) Framework, which uses agreed concepts, definitions, classifications and accounting rules to enable the organization of information into tables and accounts in an integrated and conceptually coherent way. An environmental-economic account would include information on the supply and use of products in both monetary and physical terms. Such information can be used to derive coherent indicators to inform decision-making and to provide accounts and aggregates for a wide range of purposes.

The presentation suggested establishing a satellite account framework for an extended aquaculture sector that includes upstream and downstream relationships (i.e. the entire aquaculture value chain) to facilitate the assessment of aquaculture's economic performance. An aquaculture satellite account could provide an overall framework to incorporate the environmental aspects of aquaculture.

Satellite accounts are desirable but expensive and time-consuming to construct. Possible immediate solutions include: (1) estimation of aquaculture GDP based on an ad hoc basis following methods in

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[8] Cai, J., Leung, P. & Hishamunda, N. 2009. *Commercial aquaculture and economic growth, poverty alleviation and food security: assessment framework*. FAO Fisheries and Aquaculture Technical Paper No. 512. Rome, FAO. 58 pp. (also available at www.fao.org/docrep/012/i0974e/i0974e.pdf).

[9] Available at www.fao.org/docrep/w0010e/W0010E00.htm#Contents

[10] The final draft chapters is available at http://unstats.un.org/unsd/EconStatKB/Attachment517.aspx

[11] Available at http://unstats.un.org/unsd/envaccounting/White_cover.pdf

the literature (e.g. FAO Fisheries and Aquaculture Technical Paper No. 512); and (2) development of common framework for estimating the upstream and downstream value added of aquaculture.

Presentation 17: Aquaculture's contribution to employment and poverty alleviation (by Neil Ridler)

One project includes case studies on labour governance in aquaculture in two African countries (Mozambique and Zimbabwe), four Asian countries (India, the Philippines, Thailand and Viet Nam) and one Latin American country (Chile). The results of these case studies will be published in the forthcoming FAO Fisheries and Aquaculture Technical Paper No. 575 *Improving governance in aquaculture employment: a global assessment*.

The results show that many countries have ratified protocols of the International Labour Organization (ILO) against "social dumping" (i.e. sacrificing the welfare of employees) in various aspects (e.g. health and safety, child labour, contract labour, and the right to organize), but there are possible problems in enforcing the protocols. In many cases, aquaculture is an enclave activity in a marginal area and hence is subject to monopsonist employment and wages.

The results show that young workers (age 20–39 years) accounted for 75 percent of the aquaculture labour force in the case studies in Africa, 60 percent in those in Asia, and 56 percent in Chile. The evidence indicates that aquaculture has great potential in creating jobs for young people and, hence, reducing rural–urban migration and enhancing viability of isolated communities.

The results show that female workers accounted for 75 percent of the aquaculture labour force in the case studies in India and the Philippines. The evidence indicates that aquaculture has great potential in generating employment for females and hence contributing to women's empowerment.

In all the case studies, aquaculture wage was above the minimum wage rate. In the case studies of Zimbabwe, Chile and the four Asian countries, the average wage in aquaculture was higher than comparable activities. However, in the Mozambique case study, the average wage in aquaculture was lower than in commercial fisheries. In the Chile case study, the average wage of fish farmers was twice as high as the minimum wage, whereas the basic wage of fish processing workers was only one-third higher and two-thirds of their incomes relied on bonuses.

The results show that aquaculture workers received various employment benefits, such as training (e.g. Salmon Red in Chile for unemployed salmon workers), pensions for permanent employees, health benefits (e.g. free clinics in Viet Nam), bonuses (e.g. perks offered by Lake Harvest in Zimbabwe), accommodation and meals, and preferential hiring of family members.

Based on the Chile case study, a set of indicators was used to compare the changes in socio-economic conditions in the period 1996–2006 between a salmon-farming region (i.e. X Region) and Chile as a whole.

- Growth in average household income: 28.6 percent (in the salmon-farming region) versus 10.9 percent (in Chile as a whole).
- Reduction in the ratio of poor households: 18.2 percent versus 9.5 percent.
- Increase in average years of schooling: 1.07 years versus 0.67 years.
- Increase in the ratio of households with access to drinking-water: 7 percent versus 3.2 percent.
- Increase in the ratio of households with access to electricity: 8.6 percent versus 3.6 percent.

The other project discussed in the presentation includes case studies on seaweed farming in six countries (India, Indonesia, Mexico, the Philippines, Solomon Islands, and the United Republic of Tanzania); the results of the case studies will be published in the forthcoming FAO Fisheries and Aquaculture Technical Paper No. 580 *Social and economic dimensions of carrageenan seaweed farming*.

The results show that because of characteristics such as being labour-intensive and minimum capital requirements, seaweed farming has great potential in contributing to rural employment and livelihoods, especially for very poor coastal inhabitants.

Some specific information on aquaculture employment provided by the seaweed project includes: (1) in the Philippines, seaweed farming created 100 000–150 000 jobs in cultivation and 100 000 jobs in post-harvest (drying, collecting, trading and processing); (2) in Indonesia, a family seaweed farmer had annual earnings as high as those of a middle-level bureaucrat; (3) in all the case-study countries, seaweed farming helped generate incomes for school tuition, house improvement, clothing, consumer durables, etc. ; and (4) in India and the United Republic of Tanzania, most seaweed farmers are women.

Presentation 18: Comparing value chains in fisheries and aquaculture (by Jose Fernández-Polanco)

The presentation provided some background information on price transmission in the seafood value chain:

- The ex-vessel or ex-farm price of fish, which defines the profits and welfare of fishers and fish farmers at the production end of a seafood value chain, is ultimately determined by the demand of consumers or other end users at the retail end of the value chain.
- The assumption of perfect competition seems appropriate for the fish production sector but not appropriate for the processing–distribution–retailing (PDR) sector.
- In many industrialized countries, a few supermarket chains account for a very large share of seafood retail sales; thus, non-competitive market structures and imperfect price transmission in the PDR sector may have important welfare implications for fishers and fish farmers.

The presentation introduced the FAO/Norad project on seafood value chains, which includes case studies on the value chains of selected wild and farmed fish species in selected developed and developing countries. The main objective of the FAO/Norad project is to study market competition at the different stages of various seafood value chains and the implications of different market conditions on price transmission along the value chains.

Two methods were used in the case studies to examine price transmission along a seafood value chain: One used structural models to measure variations in marketing margin, retail price and producer price; the other used reduced form models to examine co-integration among prices across the different stages of the chain.

The presentation highlighted some results of the case study on the seafood value chains in Spain:

- Different species tend to have different market conditions.
- Price transmission is less effective in wild species dominated by local landings.
- The prices of farmed species seem to be more integrated than those of wild fish.
- In the period 2004–2011, the prices of most species except mussels increased significantly, but the prices of wild species with large amount of imports decreased or increased moderately even in periods of shortage in local supply. The largest increases in ex-vessel prices were observed across species with large shares of local supply.
- In the period 2004–2011, the change in retail prices was less pronounced than that in producer or wholesale prices because retailers were able to flatten the variations of prices in earlier stages of seafood value chain.
- In the period 2004–2011, value added by wholesalers was greater for wild species with low levels of imports. The share of value added by wholesalers was lower for farmed species than wild species. Generally speaking, wholesalers reduced their contribution in the seafood value chain as retailers increased their profits.

- In the period 2004–2011, wholesalers' profits were relatively high in markets dominated by locally harvested species. However, they were lower in farmed species than wild species. As high price elasticity of consumer's demand for fish prevents retail prices from rising significantly; species with a larger wholesaler margin are less attractive to retailers.
- The prices of salmon and trout increased in the period 2004–2011, which had less impact on retailers' profits than increases in the price of wild species. Farmed species, especially those dominated by local landings, tend to generate more profits for traders.
- In the period 2008–2010, *Pangasius* generated larger profit, especially for retailers than other species. This was mainly due to low import prices and the effects of asymmetry of information resulting in comparatively high prices paid by consumers.

At the end of his presentation, Mr Fernández-Polanco provided a summary and shared some considerations:

- Retailers' interest will focus on species such as hake, anchovy and *Pangasius*, whose prices have been declining so as to allow larger profit margins. All these species have relatively high reliance on import products.
- Most farmed species except *Pangasius* had increasing prices, which resulted in lower retailers' profits. However, the decline in retailers' margins was generally less for farmed species than wild species.
- Retailers' decisions affect volumes of trade and consumption. In the observed period, species with declining prices and farmed fish species would be preferred to other wild species. The volume of trade would increase or decrease modestly.
- Generally speaking, farmed fish will benefit from declining prices.

Presentation 19: GLOBEFISH – a private sector's point of view (by Jose Estors Carballo)

The presentation introduced the FISH INFONetwork, which is composed of the FAO-based GLOBEFISH and seven independent intergovernmental and governmental organizations including INFOPESCA (South and Central America), INFOFISH (Asia and Pacific region), INFOPECHE (Africa), INFOSA (Southern Africa), INFOSAMAK (Arab countries), EUROFISH (Eastern and Central Europe), and INFOYU (China). GLOBEFISH is coordinated by FAO and funded by FAO and partners (European Union [Member organization], Norwegian Seafood Council, NOAA, Spanish Ministry for Fisheries, etc.). The seven regional/subregional/national components have been funded by corresponding member countries and the private sector.

The main publications and services provided by GLOBEFISH[12] include:

- Price reports and market trend analysis, which include two major GLOBEFISH publications. One is *GLOBEFISH European Price Report*, which is a monthly publication that provides details of current prices in European markets for more than 600 fish products through information from an extensive network of price correspondences (with the private sector). The other is *GLOBEFISH HIGHLIGHT*: *A quarterly update on world seafood markets*, which is a quarterly publication on the status and trends of major seafood commodities in global markets.
- GLOBEFISH Commodity Update, which contains data and statistics from around the world on prices, production, processing, consumption, imports, and exports for one specific seafood commodity (e.g. freshwater fish, cephalopods, groundfish, small pelagics, fishmeal and fish oil, bivalves, tuna, salmon, crab, lobster, and shrimp).
- GLOBEFISH Research Programme, which carries out market studies on topics of current importance and/or request or recommended by GLOBEFISH partners (member countries, the private sector, research communities, etc.).

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[12] GLOBEFISH home page available at: www.globefish.org/homepage.html

- GLOBEFISH DataBank (accessible only to registered members), which includes an address database that provides information on seafood companies and a statistics database that provides monthly, quarterly and annual data and statistics on seafood commodities.

The presentation noted that market information and intelligence are key to the success of seafood business; and market information and intelligence could be gathered and accumulated through visiting markets in person, attending trade fairs or expositions in different regions, networking through professional associations (e.g. chamber of commerce) with various companies for information sharing and market research, and last but not the least, Internet searches.

The presentation noted that different markets tend to entail different marketing strategies and highlighted the importance of trading agents (i.e. trading companies or commission-based representatives), who know the market, understand the culture, and possess business connections and negotiation skills to facilitate sales or contracts.

The presentation noted that long-term success in seafood business entails: (1) close connection with the market and consumers (understanding what they need and when they need it); (2) ability to provide quality products at competitive prices; (3) constant innovation; and (4) finding ways to add value to products.

Presentation 20: Developing aquaculture performance indicators (by Doris Soto)

The presentation discussed the methodology, indicators and results of an assessment of the environmental performance of salmon farming in southern Chile. The assessment used a multiple component scorecard to evaluate production efficiency (PEF), FCR, the environmental condition of farm sites, and the environmental image of the industry. One hypothesis or conjecture to be tested in the assessment was that larger companies would perform better (in terms of per tonne of salmon production) than smaller farms. The technical and performance indicators used in the assessment include:

- Physical variables: (1) mean depth of the farm site (metres); and (2) qualitative measure of current (scale 1−5).
- Technical indicators: (3) size of the company; (4) number of manual feeders (persons); (5) cage volume (cubic metres); (6) age of the farm site (years); (7) technology; and (8) stocking density (fish per cubic metre or kilograms per cubic metre).
- Performance indicators: (9) length of the cycle (months); (10) weight at harvest (kilograms); (11) mortality (percentage); (12) net P (phosphate) in sediment; (13) production volume (tonnes); (14) FCR (ratio); and (15) PEF (growth rate/month).
- Environmental integrated indicators: (16) environmental condition; and (17) image of the industry.

Simple statistical analysis and more sophisticated multivariate regression models were used to evaluate the impacts of various factors on the performance of salmon farming. The results suggested that: (1) PEF negatively affected by stocking density and the age of the farm site; (2) PEF positively affected by company size and feeding technology; (3) feed efficiency negatively affected by the number of feeders and production volume; (4) feed efficiency positively affected by feeding technology; and (5) the size of company has no significant impact on the FCR.

The presentation noted that the FCR can be a good indicator of farming efficiency, economic performance, and environmental performance (including nutrient losses and eutrophication potential, food waste, greenhouse gas contribution, etc.).

As a useful indicator of environmental and economic performance, FCR can be used in benchmarking analysis, improved by taking into consideration of mortality (i.e. biological FCR), and applied to other farmed species.

The presentation introduced the Code of Conduct for Responsible Fisheries (Code), which was unanimously adopted by FAO Members in 1995. Article 9 of the Code specifically addresses issues related to the performance of aquaculture.

Every two years, FAO distributes a general questionnaire to all Members for self-assessments of their compliance with aquaculture-related articles in the Code. A new questionnaire has been designed to improve the implementation of the Code and the reporting system, specifically, to facilitate countries' compliance and enhance the contribution of aquaculture to the present and future food security and economic development, and to improve FAO's assistance to Members. The new questionnaire includes:

(a) Essential management instruments or measures on aquaculture policies, plans and regulations.
(b) Support mechanisms to facilitate the measures included in (a), including data collection and monitoring, stakeholder consultation, integration of aquaculture to broader sector management, etc.
(c) Enhancing mechanism to improve the implementation of the measures listed in (a) and (b), including certification systems, soft credits, insurance, etc.

The presentation noted that, in order to assess the actual implementation of regulations and other management measures, there is a need for indicators that countries can use to conduct the assessment; and the Code reporting system serves the need and is expected to provide a global assessment of the performance of aquaculture governance and identify salient issues that need attention at the regional or national level.

Presentation 21: Environmental and resource constraints in aquaculture (by Trond Björndal)

The presentation revisited the well-known "fishmeal trap hypothesis", which cautions that aquaculture's dependence on fishmeal makes it inherently unsustainable and environmentally degrading.

The presentation noted that aquaculture has become the main user of fishmeal and fish oil; and there are uncertainties with respect to the sources of aqua feed. Against this background, the presentation posed the following question: In order to facilitate sustainable aquaculture development, should the use of fishmeal and fish oil be governed by a management system established by government, the economic mechanism dictated by market, or ethical principles endorsed by stakeholders in the industry?

To answer this question, the presentation first highlighted some stylized facts in the status and trends of fishmeal and fish oil production and utilization:

- World fishmeal production declined from slightly more than 7 million tonnes in 2000 to less than 5 million tonnes in 2009. Fishmeal produced from whole fish declined during the period, whereas fishmeal from fish wastes trended upwards.
- World fish oil production was stable at about 1 million tonnes in the period 2001−2011. A small number of countries (Peru, Chile, Scandinavian countries, the United States of America and Japan) accounted for most of world fish oil production.
- In Norway, the share of capture fisheries production used for production of fishmeal or fish oil declined from about 50 percent in 1990 to about 30 percent in 2007.
- Growth in global aquaculture production since 2000 has not led to increased use of marine ingredients. Substitution of fishmeal and fish oil by non-marine ingredients has been a key driver behind this situation. For example, the ratio of fishmeal in salmonid diets declined from more than 30 percent in 2000 to less than 25 percent in 2008; that of fish oil declined from more than 20 percent to 15 percent.

Based on these stylized facts, the presentation argues that: 1) the fishmeal trap hypothesis does not hold up against the data; and 2) with appropriate governance mechanisms, whether regulatory, economic or social, resource and environmental challenges in aquaculture can be solved. As an example, the presentation highlighted the large decline in the use of antibiotics in the Norwegian salmon farming industry.

The presentation noted that seafood is a more ecosystem-friendly industry compared with livestock production. For example, the estimated carbon footprint (kilograms of CO_2 emissions per kilogram of edible part at slaughter) is 0.5 for herring and mackerel production (Norway), 3.3 for haddock (Norway), 2.9 for cod and salmon (Norway), 2.7 for chicken (Sweden), 5.9 for pork (Sweden), and 30 for beef (Sweden).

The presentation noted that improved resource utilization in aquaculture is not necessarily regarded as positive at the environmental level. For example, it was estimated that Canadian Atlantic salmon farms increased their CO_2 emissions because of an increase in the use of poultry products as feed ingredients to substitute fishmeal and fish oil.

The presentation noted that, driven by competing economic interests and concerns over the environment and food safety, more stakeholders have been increasingly involved in environmental governance through various mechanisms such as certification.

The presentation used the experience of disease outbreaks in the shrimp farming industry in Taiwan Province of China in the late 1980s and that in Chile in the late 2000s to stress that governance should not be too light. It used the lack of development in the salmon industry in the United States of America to stress that governance should not be too heavy-handed so as to prevent innovations and sustainable technological development, and should recognize and respect structural changes in the industry.

The presentation noted that conflicts in relation to the use of oceans are likely to continue and increase because there are many different views with respect to sustainable use of oceans. The importance of the oceans is likely to increase as pressure on marginal lands continues to increase; and no governance is likely to lead to the worst outcome (e.g. open access). A fundamental question is whether innovation and human ingenuity would be allowed to play their part. Better and sustainable outcomes require better assessment and understanding of trade-offs among different dimensions of aquaculture development.

Presentation 22: Aquaculture and climate change: objectives and performance criteria (by James Muir)

The presentation noted that, given the continued growth and dynamic of aquaculture and various social and economic expectations over it, there is broad recognition of potential climate change impacts with and around the sector. The interest is particularly focused on aquaculture's adaptation to climate change and shifts towards "climate smart" approaches. However, the prospects for defining resilient investments and operational strategies are unclear.

The presenter introduced some activities on aquaculture and climate changes that he has been involved with:

- Global Partnership for Climate, Fisheries and Aquaculture, which is a global initiative to raise awareness of climate change interactions with fisheries and aquaculture and map strategies to address the change.
- Development of strategies for sector-related disaster risk reduction/management (DRR/DRM) and climate change in Africa.
- FAO's review on energy and greenhouse gases (GHGs) in the fisheries sector.
- Providing sectoral inputs into the NRC/WB Climate Smart Agriculture programme.
- Providing inputs to the "Fish to 2030" project by WB/IFPRI/FAO.

The presentation noted that potential biophysical changes from global warming would have impacts on ocean currents, sea levels, rainfall, river flows, lake levels, thermal structure, storm severity, storm frequency, acidification, etc. The changes would affect different aspects of fisheries and aquaculture and have various technical, environmental, economic and social impacts:

- By affecting production ecology, climate changes would have impacts on species composition, production and yield, distribution and seasonality, disease and other disruptions, coral bleaching, and calcification.
- By affecting fishing, aquaculture and post-harvest operations, climate changes would have impacts on safety and security, efficiency and costs, and infrastructure security.
- By affecting communities and livelihoods, climate changes would have impacts on loss or damage to assets, risks to life and health, vulnerability and confidence, and displacement and conflict.
- By affecting wider society and economy, climate changes would have impacts on the costs of mitigation and adaptation, social and market impacts, and water or other resource allocation.

The presentation noted that: (1) the potential impacts of climate changes on a country or region's fisheries and aquaculture sector are determined by the sector's exposure to climate changes and the country or region's dependency on the sector; and (2) the vulnerability of the sector to climate changes is determined not only by the potential impacts but also by its adaptive capacity.

The presentation highlighted a series of measures and indicators of the vulnerability of fisheries and aquaculture to climate changes:

- Exposure indicators:
  - Sea-level rise: (1) percentage of province area flooded.
  - Temperature rise: (2) average temperature increase relative to the baseline.
  - Rainfall change: (3) annual rainfall change relative to the baseline.
  - Coastal extreme events: (4) aquaculture area damaged due to storms and typhoons.
  - Floods: (5) aquaculture area damaged by floods.
- Dependence indicators:
  - Direct livelihood: (6) percentage of households engaged in aquaculture.
  - Indirect employment: (7) employees in fishery enterprises as percentage of total enterprise employees.
  - Macroeconomics: (8) fisheries sector output as percentage of country GDP.
  - Food security: (9) per capita annual seafood consumption.
- Adaptive capacity indicators:
  - Poverty: (10) percentage of population below poverty line; (11) percentage of household monthly food expenditure spent on seafood.
  - Infrastructure: (12) telephone lines per 100 people; (13) number of hospital beds per 1 000 people.
  - Education: (14) graduates of secondary education as percentage of total candidates.
  - Disaster response to climate changes: (15) number of disaster management programmes; (16) DRM investment in construction projects; (17) DRM investments in non-construction projects.
  - Social capita: (18) share of fishery/aquaculture cooperatives as percentage of national total.
  - Education: (19) percentage of fishery/aquaculture employees with education.

The presentation discussed approaches for scoping the impacts of climate changes, including: (1) defining sectors and interactions through supply, value and benefit chains; (2) understanding key functional relationships and variability across defined sectors/locations; (3) clarifying probability definitions of key climate change variables (possible cascading effects); (4) conducting assessments of capacity (short and longer term; low to high magnitude); (5) considering wider interactions with other sectors and systems (compounded effects or mitigation/moderation potential); and (6) incorporating specific contexts (location in resource, productive efficiency and/or market roles).

The presentation highlighted that mapping out the different aquaculture systems in use worldwide, their significance (e.g. people involved, production quantity and value) and climate disturbance level (minor, significant and major) in terms of issues and responses, could represent a valid starting point for planning future options.

The presentation noted that climate-related sector objectives may include: (1) recognition of impact/risk profiles; (2) means of defining or forecasting key impacts; (3) response options and features; (4) minimizing downside and identifying or promoting possible win–win options; (5) wider awareness of specific issues, and (6) investment needs across a range of elements.

Presentation 23: Water use in aquaculture (by Daniela Ottaviani)

The aim of the presentation was to present some methodological issues related to the measurement of water use in aquaculture. Measuring water use in aquaculture is important in order to allow aquaculture to be compared with other sectors such as agriculture, industry and domestic use.

As recommended by the International Recommendations for Water Statistics, water utilization is commonly measured in volume of water (cubic metres). However, assessing volumes of water used in aquaculture from the known surfaces of aquaculture ponds is not straightforward.

When a simple aquaculture fish pond is considered, the water budget of the pond is given by water addition (precipitations, inflow caused by runoff, inflow caused by groundwater seepage, etc.) and by water reduction (evaporation, outflow caused by overflow and regulated discharge, outflow caused by infiltration, etc.).

Among all these water exchanges, the only water flow considered consumptive water use is the net amount of water lost by evaporation, while the other water exchanges recorded at the level of the aquaculture fish pond (i.e. runoff, seepage, discharge, infiltration) can be considered as water exchanges within the water cycle occurring at the watershed level.

Considering only consumptive water use (i.e. net evaporation/evapotranspiration) does not properly describe the operational use of water in aquaculture. Aquaculture facilities can be constituted by open (e.g. ponds and tanks) as well as closed systems (e.g. recirculating aquaculture systems). Water budgets in open vs closed aquaculture facilities greatly differ in the amount of direct water use such as: inflow caused by net evaporation, inflow caused by water addition, outflow caused by drainage, outflow caused by discharge.

A comprehensive assessment of water use in aquaculture should not consider only direct water use, but also indirect water use (i.e. water use associated to the amount of water needed to produce grains used in industrial aquafeed). Usually direct and indirect water uses are inversely related. When aquaculture production becomes more intensive, direct water use tends to decrease while indirect water use tends to increase.

Operationally, the intensity of aquaculture production is highly dependent on the quantity of water flow through the aquaculture system. In this respect, an interesting measure of water use in aquaculture would be the quantification of grey water (i.e. the volume of freshwater that is required to assimilate the load of pollutants or nutrients based on natural background concentrations and existing ambient water quality standards). Thus, in order to assess the water use of aquaculture at the national level, is it possible to go beyond the estimates of evaporation and indirect water use to account for the concept of grey water used in aquaculture systems?

Presentation 24: Global Aquaculture Performance Index (GAPI) (by Jennifer Gee)

The presentation introduced the Global Aquaculture Performance Index (GAPI), which was a project funded by the Lenfest Ocean Programme and supported by the Pew Environment Group.

The presentation noted that: (1) GAPI is a mariculture specific application of the Environmental Performance Index (EPI) methodology developed by researchers at Yale and Columbia Universities; (2) GAPI covers 93 percent of global marine finfish aquaculture production; and (3) GAPI is focused on policy-relevant environmental outcomes and uses a proximity-to-target methodology (not relative ranks) to quantify outcome. Proximity of each country-species to each environmental target provides a factual and quantitative foundation of performance for that environmental indicator.

The presentation clarified that the goal of GAPI is not to measure every conceivable metric but to focus on key priority impact areas identified as being most important in discriminating leaders from laggards. Taking into account four principles (relevance, performance orientation, transparency and data quality), and guided by sustainability indicators used in a number of other seafood sustainability initiatives, GAPI pins down ten key environmental impact indicators:

- Indicators related to inputs: (1) capture-based aquaculture, (2) ecological energy, (3) industrial energy, and (4) sustainability of feed.
- Indicators related to discharges: (5) antibiotics, (6) antifoulants (copper), (7) biochemical oxygen demand (BOD), and (8) parasiticides.
- Indicators related to the biological impacts of aquaculture: (9) escapes, and (10) pathogens.

The presentation noted that creating the above indicators and setting out the formulas for each was a complex exercise; the details can be found at the GAPI webpage: www.gapi.ca.

The building blocks of GAPI include: 1) "species–country scores", which measure the environmental impacts of a country's farming of a species; 2) "country GAPI scores", which measure the overall impact of a country's farming of all marine finfish species; and 3) "species GAPI scores", which measure the impact of the farming of a species by all countries.

GAPI includes two types of scores: (1) normalized scores measure performance in terms of per unit of production, while (2) cumulative scores measure performance in terms of total production.

The presentation noted that GAPI is not a standard but a performance metric aiming to measure and compare the environmental performance of different mariculture practices.

The presentation used several examples to explain some key points of the measuring process, which include: (1) setting zero ecological impact as a common and unmoving benchmark target for comparison; (2) using the species–country GAPI score to measure the "distance" separating a player from the zero impact benchmark – the greater the distance, the worse the score; (3) using the difference between two species–country GAPI scores to compare the relative performance of two farming practices; (4) using the difference of country GAPI scores to compare the performance of different countries; and (5) using the difference of species GAPI scores to compare the performance of different species.

The presentation noted that, generally speaking: (1) young and fast-growing (marine finfish aquaculture) industries tend to have relatively low normalized scores as well as low cumulative scores; (2) mature industries tend to have relatively high normalized scores (indicating their relatively high environmental efficiency) but relatively low cumulative scores (reflecting their relatively large environmental impacts because of their large production); and (3) intermediate industries tend to have a rising normalized score but a declining cumulative score.

The presentation introduced the application of GAPI to comparing the environmental benefits of marine aquaculture standards. The overarching question addressed by the benchmarking analysis is: what is the minimum environmental performance required to meet a standard or certification?

The presentation noted that the result of the analysis indicated that a majority of labels offer limited performance gain over non-labelled product – a very modest return on investment and a sobering snapshot of the state of the sustainable aquaculture movement.

The presentation noted that adoptability of standards has often been treated as a secondary issue in ideologically driven ecolabels.

The presentation noted that almost all consumer-facing labels reflect performance on a normalized level (i.e. in terms of per individual fish); and industry-based initiatives are all normalized to performance per tonne or production cohort.

The presentation pointed out that such focus on "unit impact" may convey an incomplete message about the performance of aquaculture. Using the example of Atlantic salmon, which has a high normalized score (i.e. high environmental efficiency in terms of per unit of production) but a low cumulative score (i.e. large overall environmental impacts), the presentation argued that cumulative performance is also an ecologically relevant metric; and that, ultimately, ecological performance should be measured by cumulative impacts.

The presentation noted that: 1) GAPI has been used by some ecolabelling initiatives (such as Monterey Bay Aquarium's Seafood Watch guide and Salmon Aquaculture Dialogues) for development of standards; 2) GAPI has also been included in the prototype WAPI tool to illustrate the assessment of the environmental impacts of aquaculture; and 3) there is ongoing work to extend GAPI into a farm-level tool to evaluate performance at the farm level and allow producers to assess their performance at an individual level.

Presentation 25: Different approaches on measuring the net impact of aquaculture (by Neil Ridler)

Based on a case study on comparing salmon monoculture versus integrated multitrophic aquaculture (IMTA) in New Brunswick, Canada, the presentation compared three methods often used in sector assessment, i.e. social impact assessment (SIA) based on input–output models, analytical hierarchy process (AHP) and cost–benefit analysis (CBA).

The presentation highlighted that two key steps of SIA are: (1) surveying salmon farms to obtain the value of salmon farming production and processing in New Brunswick; and (2) using input–output coefficients to estimate the impacts of salmon farming on jobs and GDP for New Brunswick and Canada as a whole. The results indicated larger multiplier impacts for Canada than New Brunswick.

The SIA estimation results indicate that salmon farming contributed to 0.22 percent of New Brunswick's GDP directly and helped generate 0.17 percent of the GDP through its indirect impact and 0.11 percent through its induced impact. Thus, the overall impact of salmon farming on New Brunswick's economy amounted to 0.5 percent of its GDP.

The SIA estimation results indicate that salmon farming contributed to 4.6 percent of New Brunswick's employment (measured by the number of full-time equivalent jobs) directly and helped generate 2.7 percent of its total employment through the indirect impact and 1.9 percent through the induced impact. Thus, the overall impact of salmon farming on New Brunswick's employment amounted to 9.2 percent of its total employment.

The presentation noted that the AHP approach allows decision-makers to balance the trade-offs of multiple dimensions of aquaculture. For example, in the salmon farming case study, stakeholders were asked to consider trade-offs between socio-economic benefits (rural employment, viability of communities, traditional marine way of life, etc.) and environmental costs (visual intrusions, impacts on fisheries, water pollution, etc.).

The AHP approach provides a scientific, pair-wise comparison process to reveal the "priority weights" of decision-makers over different dimensions. The results indicate that pollution and employment were the first two dimensions that matter the most to the stakeholders in the two salmon farming counties.[13]

The presentation noted that the CBA approach usually includes five steps: (1) identification of project; (2) assessment of technical feasibility; (3) conducting financial analysis (net present value or the internal rate of return); (4) estimating total economic value by adjustments for distortions (shadow prices vs market prices), evaluation of externalities, and use of the social discount rate; and (5) conducting risk assessment through sensitivity analysis.

In the case study, both financial analysis and the total economic value approach indicate that IMTA is preferable to monoculture salmon farming in all three scenarios (optimistic, pessimistic and mixed).

In sum, the case study results indicate that: (1) in terms of credibility of information, SIA ranks first, AHP second, and CBA last; (2) in terms of the pertinence of information, the ranking is AHP, CBA and SIA; and (3) in terms of resource implications (i.e. money, time and skills required for the assessment), the ranking is SIA, AHP and CBA.

Presentation 26: Environmental performance of aquaculture: trade-offs and net impact (by John Hambrey)

The presentation pointed out that individuals, businesses, regions and countries need "performance indicators" to measure how well they are doing in the pursuit of social, economic and environmental objectives. These indicators should be related to both the costs and benefits of aquaculture production, but specific indicators are needed at different levels (international, national and farm) tend to differ.

The presentation noted that many farm or sector impact indicators measuring aquaculture's costs (energy use, resource use, land use, use of chemicals, use of antibiotics, wastes, etc.) and benefits (gross revenue, value added, employment, nutrition, etc.) provide separately useful information but are not "performance indicators" because they do not assess the trade-offs between benefits and costs.

The presentation noted that "process efficiency measures" (e.g. FCR, energy consumption per kilogram of product, carbon emission per kilogram of product, land use per kilogram of product, waste per hectare, and waste per kilogram) are indicators of technical performance, important for farmers themselves, and can be used to drive improved process performance. However, such indicators are of limited value for sector performance assessment, monitoring and planning because the objective of society is not to maximize technical efficiency (measured by weight), but rather to maximize the ratio of social or economic benefit to unit input or waste.

The presentation clarified that "performance" means the efficiency of achieving objectives, which may include: (1) maintaining environmental quality and biodiversity within agreed standards; (2) minimizing the use of limited natural resources; and (3) maximizing social and economic benefit. The overall efficiency of achieving these objectives can be understood as "maximizing social and economic benefit per unit of environmental cost".

Based on this conceptual framework, the presentation suggested that measures of economic-environmental efficiency, such as use of energy/land/fishmeal per unit of value added (or per unit of

[13] The results indicate that the priority weights of stakeholders in Charlotte County and Saint John County were 62.5 and 61.2 (respectively) for pollution, 16.3 and 13.3 for employment, 7.6 and 11.1 for coastal communities, 6.7 and 6.1 for capture fisheries, 5.3 and 5.9 for traditional lifestyle, and 1.6 and 2.4 for visual impacts.

job) and generation of waste per unit of value added (or per unit of job), should be more relevant "performance indicators" for comparing technologies and economic development planning, and for measuring development progress.

The presentation emphasized that data benchmarks or reference points for these indicators are essential to maximizing benefit under given costs and/or maximizing benefit within the carrying capacity of the environment.

The presentation noted that the objective of no significant negative social and environmental impacts in the process of development is desirable but often not possible, whereas a more realistic goal is to achieve an acceptable trade-off between social, economic and environmental objectives. Several potential trade-offs include: (1) "limited use of space/habitat" versus "efficient use of inputs" or "minimizing pollution"; (2) "local land use" versus "ecological footprint"; (3) profit margin versus profit per hectare; (4) use of fishmeal and/or fish oil in aquafeed versus the nutritional quality of the product, among others.

The presentation used an example to illustrate the importance of selecting proper performance indicators. It was noted that although IMTA as an environmentally efficient aquaculture technology may have a high profit margin (i.e. profit as a percentage of revenue), it could be unattractive to farmers with limited land resources because of the low total profit. This is probably why IMTA has not taken off despite being promoted since the late 1960s, and why there has been such a radical shift to intensive feed-based systems even for species such as tilapias and carps.

The presentation noted that deciding how to assess and address trade-off issues and, ultimately, make an assessment of net benefit is subjective, related to society's values or local circumstances, and should therefore be a political/democratic decision informed by unbiased analysis and effective communication of performance characteristics.

The presentation listed and commented on three methods of communication of trade-offs:

- Presenting all possible individual trade-offs identified by technical specialists: This method is too complex, not liked by decision-makers, and does not drive improved performance.
- Synthesis and aggregation – technical specialists generate overall measures of net impact. This method is much simpler, liked by decision-makers where opinions are diverse and not polarized. However, the assessment process is in a black box with technocrats rather than politicians weighting the values/trade-offs and determining the outcome. This method also does not readily drive improved performance.
- Periodic identification and communication of key trade-offs by expert and stakeholder advisory groups. This method is transparent and drives improved performance.

The presentation noted that indicators that summarize economic–environmental efficiency (e.g. feed use per unit of value added) can be used to: (1) compare systems/technologies and to monitor and promote improvements; and (2) address some trade-off issues by integrating environmental and economic objectives. However, such indicators do not address cumulative sector impact, which is arguably something that must be addressed in the specific context (e.g. local environmental standards).

In conclusion, the presentation:

- Noted that it is important to be clear on why and for whom the net impact is measured. For policy-makers, net impact is assessed mostly to decide or agree on acceptable trade-offs; whereas for farmers, performance indicators could be used to promote environmental improvement (e.g. a higher ratio of financial benefit to environmental degradation).
- Reiterated that there has been too much historic emphasis on process indicators and a misleading emphasis on weight of production as the important measurable output.

- Recommended presenting and monitoring performance in several key dimensions of direct relevance to farmers and politicians, rather than aggregating all dimensions into a single net benefit figure.
- Noted that some relatively simple economic environmental indicators would be powerful tools to promote better environmental practice at minimum social and economic cost.

Presentation 27: Impact of aquaculture under various policy scenarios (by Madan Dey)

The presentation noted that, based on different stages of the discovery–adoption–impact pathway, there are three types of impact assessment:

- *Ex ante* impact assessment and priority setting whose main objective is to provide basis for setting priorities among alternative research options.
- Monitoring and evaluation whose main objective is to provide feedbacks to researchers regarding their clientele's need, and thus improve the design of research.
- *Ex post* impact assessment whose main objective is to demonstrate the value or otherwise of the research.

Based on interactions with other sectors; there are two types of impact assessment, i.e. partial equilibrium and general equilibrium.

The presentation discussed a project on "Development and dissemination of integrated aquaculture – agriculture technologies in Malawi". Indicators used in the project to measure the socio-economic impacts of integrated aquaculture–agriculture (IAA) technology are summarized as follows.

- Indicators of efficiency (house/community/region/nation): (1) resource productivity; (2) fish production and its growth; (3) profitability of aquaculture; (4) input saving; (5) income from aquaculture and its growth; (6) farm income; (7) producer's welfare (surplus); (8) consumer's welfare (surplus); and (9) increased export and decreased import.
- Indicators of food and nutrition: (10) food consumption by household members, by income class, or by rural/urban population; (11) fish consumption by household members, by income class, or by rural/urban population; and (12) better health status of family members.
- Indicators of employment: (13) labour use in aquaculture by gender and age groups; and (14) employment opportunity in the community/region/country by gender group.
- Indicators of environment (sustainability): (15) soil quality; (16) nitrogen balance; (17) diversification of farm enterprise; (18) recycling and integration with other farm enterprises; (19) sustainability of output; and (20) resilience to drought.
- Indicators of institution: (21) farmers' skills; (22) increased capacity of farmers organizations; and (23) strength of national institutions.

The presentation noted that a two-stage analytical approach was used to estimate the "adoption function", which captures the factors affecting a farmer's decision on whether to adopt IAA and, if yes, the level of integration. The results indicate that: (1) extension, training in IAA, and number of farm enterprises have a statistically significant positive effect on the adoption of IAA technology; (2) farm size has a statistically significant positive effect on the level of integration; (3) homestead or upland farmers who adopted IAA technology tend to allocate more land to growing vegetables; (4) the impacts of IAA include 76 percent higher farm profitability, 163 percent higher per capita fish consumption, and 23 percent higher per capita protein expenditure; and (5) IAA farmers generally had higher technical efficiency and farm income than non-IAA farmers.

The presentation noted that an economic surplus analysis indicates that the adoption of IAA generated about USD3.5 million net present value of benefits; 69 and 31 percent of which are consumer surplus and producer surplus, respectively. The benefit–cost ratio (BCR) of IAA adoption is 1.56; the internal rate of return is 15 percent.

The presentation noted that, based on data gathered from long-term RESTORE monitoring, the key impacts of IAA on environmental sustainability include: (1) better resilience against drought (measured by farm income per hectare);[14] (2) better maize yield (tonnes per hectare),[15] (3) less nitrogen (N) loss (milligrams of N per square metre per day),[16] and (4) better N use efficiency (N yield per kilogram of N applied).[17]

Regarding institutional impacts, the presentation noted that the use of the IAA approach: (1) was endorsed by local government agencies and NGOs; (2) was used to help HIV/AIDS affected and infected households; (3) has led to empowerment of women and child-headed households; and (4) has resulted in spillover effects on neighbouring countries (Zambia and Mozambique).

The presentation also discussed several examples of disaggregated fish sector models with interactions among various fish subsectors, including: (1) AsiaFish model; (2) a study on the "impact of genetically improved carp/tilapia strain in Asia"; and (3) the US-Catfish model.

Presentation 28: System of environmental and economic accounting (SEEA) (by Daniela Ottaviani)

SEEA is an accounting system at the national level aimed at describing the contributions of the environment to the economy and the impacts of the economy on the environment. It measures stocks and flows by using both monetary and physical units. It includes four different modules: (1) "supply" and "use" tables that describe the flows of goods and services within the economy and the flows of natural inputs and residuals between the economy and environment during a period of time; (2) "asset" accounts that reflect the status of resources and capital at a specific point of time; (3) "economic" accounts that highlight different economic aggregates; and (4) "functional" accounts that record transactions about economic activities for environmental purposes.

The presentation illustrated several examples of accounting tables related to water and fish resources.

An asset account of water describes: (1) the freshwater stock at the beginning of the accounting period; (2) the increase in freshwater from precipitation, return flows, etc.; (3) the reduction in freshwater owing to abstraction, evaporation, climate changes, etc.; and (4) the freshwater stock at the end of the accounting period (i.e. closing stock).

The supply and use account for water use contains three main entry categories (i.e. "inputs", "products" and "residuals") and describes the different share of flows among different stakeholders (i.e. industries, households, capital, foreign countries, and environment).

The asset account for aquaculture (or capture fisheries) describes: (1) the fish biomass at the beginning of the accounting period (i.e. opening stock); (2) the growth in fish biomass (farmed or natural); (3) the reduction in fish biomass (harvest, natural mortality, catastrophic losses, discards, etc.); and (4) the fish biomass at the end of the accounting period (i.e. closing stock).

Establishing the water use of inland capture fisheries and aquaculture in a supply and use account has some challenges, particularly related to the fact that water surfaces rather than water volumes better represent areas used by inland capture fisheries and to a broad extent also water use by aquaculture especially in developing countries. Measuring water use by inland capture fisheries and aquaculture in water volume would imply quantifying at national level: (1) the natural water flow required to sustain ecological processes and consequently inland fisheries activities for inland fisheries and aquaculture: and (2) the freshwater withdrawal net of recycling capacity and water residuals.

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[14] An average IAA farmer receives 18 percent more per hectare farm income than a non-IAA farmer.
[15] IAA farmers (4–6 tonnes/ha) versus best progressive non-IAA farmer (up to 3 tonnes/ha).
[16] IAA with pond sediments (5 mg) versus non-IAA (10 mg).
[17] IAA farmers (0.4–0.6) versus non-IAA farmers (0.2–0.3).

SEEA is meant to be a tool for assessing and comparing the depletion of a given resource against a potential economic gain. However, SEEA has several weaknesses related mainly to its accounting structure: (1) the physical accounts reflect the quantity but not the quality of physical asset; (2) regarding monetary accounts, some natural resources and ecosystem functions do not have market value; and (3) market price does not always reflect the true scarcity because of irrational behaviours or market failures.

SEEA has several advantages: (1) it provides a common statistical standard that would facilitate comparison among countries; (2) its modular structure makes it flexible in implementation; (3) the coherence and consistency needed for its preparation would highlight potential data gaps that need to be filled; and (4) the use of physical units allows the inclusion of environmental assets even where the monetary values of these assets are not accountable.

APPENDIX 4

WORLD AQUACULTURE PERFORMANCE INDICATORS: A USER-FRIENDLY TOOL FOR ASSESSING AND MONITORING AQUACULTURE SECTOR PERFORMANCE

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ABBREVIATIONS AND ACRONYMS

ANTI	Antibiotics
APR	Annual percentage rate
AQ	Aquaculture
BOD	Biochemical Oxygen Demand
CAP	Capture Based Aquaculture
CIF	Cost, Insurance and Freight
COP	Copper
ECOE	Ecological Energy
ESC	Escapes
FAO	Food and Agriculture Organizations of the United Nations
FAO/FI	FAO Fisheries and Aquaculture Department
FCR	Feed conversion ratio
FI	Fisheries
FOB	Free on Board
GAPI	Global Aquaculture Performance Index
GDP	Gross Domestic Product
IFPRI	International Food Policy Research Institute
IMF	International Monetary Fund
INDE	Industrial Energy
kg	kilogram
L	Litre
LC	Lethal concentration
LCU	Local currency unit
mg	milligram
NIFES	National Institute of Nutrition and Seafood Research (Norway)
NPP	Net Primary Productivity
OECD	Organisation for Economic Co-operation and Development
OIE	World Organisation for Animal Health
PARA	Parasiticides
PATH	Pathogens
RCA	Revealed comparative advantage
SERG	Seafood Ecology Research Group
SOFIA	State of World Fisheries and Aquaculture
UN	United Nations
WAPI	World Aquaculture Performance Indicators
WB	World Bank
WDI	World Development Indicators
WEO	World Economic Outlook
WHO	World Health Organization

1. Objectives and functions of the tool

Aquaculture is a fast-growing sector with complex environmental, economic and social impacts, which can affect its overall performance. While the existing literature provides extensive information on the qualitative assessment of the complex socio-economic impacts of aquaculture on society, quantitative information about these impacts is limited.

Quantitative evaluation of the sector is essential when assessing its relative performance with respect to other sectors with which it competes for productive resources. Knowledge of the relative performance of the sector would help policy-makers make guided and informed decisions as to how to allocate limited public resources among different sectors of the economy.

Where available, quantitative information on aquaculture sector performance tends to be scattered in the literature, which leads to available information being underutilized and sometimes misused. Misusing data from different sources (or even the same source) to create incorrect or misleading indicators is not an uncommon phenomenon.

In light of this situation, FAO Fisheries and Aquaculture Department (FAO/FI) is developing a user-friendly tool to compile, generate and provide easy access to quantitative indicators on aquaculture sector performance at the national, regional and global levels.

The tool is tentatively named the World Aquaculture Performance Indicators (WAPI) tool. The primary users of the WAPI tool are professionals in the aquaculture and fisheries sector, including planners, managers, analysts and researchers, among others. The WAPI tool is intended to be a user-friendly instrument that helps experts utilize data and information from various sources to assess and monitor aquaculture sector performance in social, economic and environmental terms and detect important trends in parameters of interest to the sector.

One function of the WAPI tool is to provide templates to facilitate data compilation. The tool is composed of various templates that generate or present indicators in certain ways for assessment and monitoring of aquaculture sector performance. Inclusion of the indicators and development of the templates is based on the literature on sector performance assessment. Although some templates cover only a limited number of countries (sometimes only one country), they provide examples of what could be done and, hence, motivate other countries to collect and supply data to enrich the templates.

Another function of the WAPI tool is to provide convenient access to quantitative indicators. The tool includes data templates and indicator templates. By selecting parameters (country, species, year, indicator, etc.), users can obtain data stored in data templates through various tables and figures in the indicator templates. When data templates are changed, the tables and figures in corresponding indicator templates will be automatically updated.

It should be noted that the WAPI tool is not merely a database for storing data and quantitative indicators. Indeed, the main function of the tool is to present data and quantitative indicators in such ways as to facilitate generation of useful quantitative information for policy decision-making and sector management. Simple analyses such as comparisons across time, countries, species and products have been standardized for many indicators in the draft tool. The draft tool also includes some advanced analysis such as measuring correlations between variables, demand and supply projections, etc. However, there is still plenty of room for improvement and expansion.

Tables and graphs in the tool can be linked to corresponding sources of information and data for users to obtain more contextual information. The tool can also be used to gain broader information and deeper understanding of specific aspects of aquaculture sector performance for a given country, region or the entire world.

As the tool consolidates enough information, templates can be developed to address specific policy or management issues. It is also feasible to develop or incorporate weighting schemes, performance indices or other processes to measure the net impact (i.e. overall performance) of the aquaculture sector.

The tool can be used to help generate policy briefs, factsheets or other thematic reports for policy-making or sector management.

2. Basic structure and contents of the tool

The tool is an Excel-based instrument developed in Microsoft Excel 2007. There are two kinds of templates in the tool. One is data templates for storing or updating data. The other is indicator templates that utilize data stored in data templates to produce and present quantitative indicators.

2.1 Data templates and sources

A typical data template is shown in Figure A1. Variables such as countries, species, indicator, data source, unit, etc. are in the long form (i.e. put in columns), whereas year is in the wide form (i.e. placed in rows). In the situation where the dataset is too large, variables other than year may also be stored in the wide form.

It would be convenient to store all data in one data template so that codes for obtaining data can be more standardized. However, this would slow the process of procuring data from data templates to indicator templates. Moreover, putting data from different sources in one template would make the updating process cumbersome. Therefore, a general principle used in the draft tool is to put data from different sources in different data templates.

FIGURE A1

An example of a data template

	B	C	D	BH	BI	BJ	BK	BL	BM
1	countries	species	indicator	2005	2006	2007	source	unit	
2	Armenia	Bovine meat	Per capita food	14.67732	16.61322	15.93921	FAOSTAT F	kg/capita/year	
3	Armenia	Meat	Per capita calories	158	174	206	FAOSTAT F	kcal/capita/day	
4	Armenia	Eggs	Per capita food	6.197092	5.537741	6.180508	FAOSTAT F	kg/capita/year	
5	Armenia	Ovine meat	Per capita calories	18	17	17	FAOSTAT F	kcal/capita/day	
6	Armenia	Vegetal product	Per capita calories	1773	1720	1736	FAOSTAT F	kcal/capita/day	
7	Armenia	Offals	Per capita protein	1.7	1.7	1.9	FAOSTAT F	g/capita/day	
8	Armenia	Cephalopod	Per capita protein		0.000405	0.000539	FAO-FI Fi	g/capita/day	
9	Armenia	Meat	Per capita protein	10.8	11.1	13	FAOSTAT F	g/capita/day	
10	Armenia	Eggs	Per capita fat	1.6	1.5	1.7	FAOSTAT F	g/capita/day	
11	Armenia	Fish & meat	Per capita food	31.40791	31.68822	39.22667	FAOSTAT &	kg/capita/year	
12	Armenia	Meat	Per capita fat	12.5	14	16.6	FAOSTAT F	g/capita/day	
13	Armenia	Seafood	Per capita protein	0.645375	0.398347	0.636188	FAO-FI Fi	g/capita/day	
14	Armenia	Seafood	Per capita fat	0.18474	0.133789	0.197805	FAO-FI Fi	g/capita/day	
15	Armenia	Fish & meat	Per capita protein	11.44538	11.49835	13.63619	FAOSTAT &	g/capita/day	
16	Armenia	Vegetal product	Per capita fat	21.4	21.5	22.8	FAOSTAT F	g/capita/day	
17	Armenia	Milk	Per capita food	139.9238	125.0878	135.9712	FAOSTAT F	kg/capita/year	
18	Armenia	Seafood	Per capita calories	4.484096	2.960618	4.552413	FAO-FI Fi	kcal/capita/day	
19	Armenia	Fish & meat	Per capita fat	12.68474	14.13379	16.79781	FAOSTAT &	g/capita/day	
20	Armenia	F&D finfish	Per capita food	0.052186	0.108428	1.209381	FAO-FI Fi	kg/capita/year	
21	Armenia	Demersal finfis	Per capita calories	0.032662		0.024347	FAO-FI Fi	kcal/capita/day	
22	Armenia	Animal fats	Per capita calories	65	62	72	FAOSTAT F	kcal/capita/day	
23	Armenia	Eggs	Per capita protein	1.8	1.6	1.8	FAOSTAT F	g/capita/day	

2.1.1 Official statistics published regularly

Official statistics published regularly provide plenty of data that can be directly harnessed by the tool. Data from the following official data sources have been utilized in the draft tool:

- FAO FishStat,
- FAOSTAT,
- UN Comtrade ,
- IMF World Economic Outlook (WEO),
- World Development Indicators (WDI), World Bank,
- China Fishery Statistics Yearbook.

The information technology revolution is making data increasingly available and accessible. Most of the data included in the draft tool are obtainable from the Internet. There are still plenty of data in large comprehensive databases (such as World Development Indicators and FAOSTAT) yet to be harnessed by the tool.[1]

2.1.2 Ad hoc official statistics

Some official statistics sources contain large quantity of data but are not published regularly. One example is the FAO/INFOOD Food Composition Database, which summarizes data on food composition from a large body of literature.

[1] Data on more than 8 000 indicators are available for downloading on the website of the World Bank (http://data.worldbank.org/).

Some official data may not even be published as publically available datasets. For example, data on employment and land use in aquaculture have been collected by FAO/FI but not published as regular statistics because of concerns over quality and regular availability.[2]

Such ad hoc official statistics sometimes need to be cleaned up before they can be used to develop indicator templates. For example, different samples of nutrition composition of the same fish product in the FAO/INFOOD database need to be averaged to derive a unique observation of nutrition composition for each fish product.

The FAO/INFOOD Food Composition Database is the only ad hoc official database utilized in the draft tool. It is expected that more and more ad hoc official statistics will be available in the future. Indeed, some organizations (e.g. ILO) even place unprocessed raw datasets on the Internet for free download (http://laboursta.ilo.org/).

2.1.3 Data scattered in the literature

Data collected by surveys or case studies on aquaculture have often been used to generate specific information circulated through specific publications. Such "reduction" processes are wasteful because much more information could have been extracted had the data been processed more systematically for public use.

Cleaning up data tends to be a cumbersome and time-consuming process. Because of time and resource constraints, the draft tool includes little scattered data in the literature. However, developing standardized indicator templates can become a mechanism to consolidate such scattered data.[3]

Users of first-hand data collected from surveys or case studies would have incentives to develop standardized indicator templates, which can help them better organize, present and update information extracted from the data. Actually developing standardized indicator templates tends to be an enlightening and thought-provoking process that amplifies itself. Many indicator templates included in the draft tool were not originally planned but inspired by development of other templates.

Without specific purposes, there may be little incentive to develop standardized indicator templates based on outdated data scattered in the literature. However, some studies did compile historical data from the existing literature in order to answer some important questions. For example, in the WorldFish Center publication *Blue Frontier: Managing the environmental costs of aquaculture*, data on a number of aquaculture species farmed under various production systems in a group of countries were compiled to estimate the environmental costs of aquaculture. The report presents only the estimated results, while detailed data and analyses are not included. While it may not be practical to put massive data and analyses in the report, standardized indicator templates can be developed to present the data and analyses, which will not only enhance the understanding of the estimated results but also could induce more insights on the subject (i.e. the environmental costs of aquaculture).

[2] Some data on employment in aquaculture have been published in *The State of World Fisheries and Aquaculture* (SOFIA).

[3] Some data on aquafeed provided by Mohammad Hasan based on various publications have been used to develop sample indicator templates on use of feed in aquaculture.

It is worth noting that the Global Aquaculture Performance Index (http://web.uvic.ca/~gapi/) developed by the Seafood Ecology Research Group (SERG) at the University of Victoria (Canada) is a laudable role model of keeping data and analyses transparent. It is such transparency that allows us to utilize their data and results to produce a number of sample templates for the environmental costs of aquaculture in the draft tool.

As a public good, standard indicator templates should be developed for ongoing or potential surveys or case studies in aquaculture. Indeed, developing standard indicator templates should become an integral component of any project in aquaculture that involves data collection.

2.2 Indicator templates

A typical indicator template includes a selection menu, tables and graphs (Figure A2). The selection menu allows users to select various parameters such as indicators, countries, species, years, etc. After parameters are selected, click the "CALCULATE" button to obtain graphs and figures.

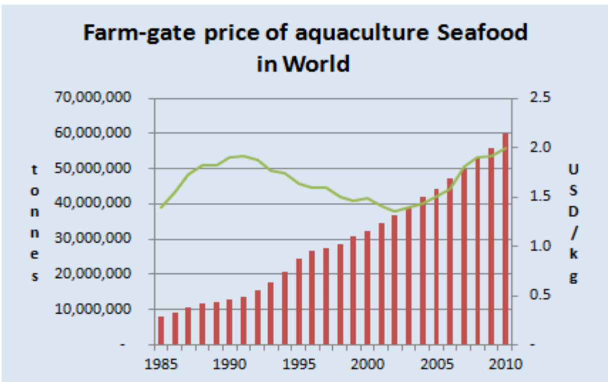
FIGURE A2

An example of an indicator template

Farm-gate prices of aquaculture production		Unit	Source
Species:	Seafood	USD/kg	FAO-FISHSTAT
Country or Area:	World		
Ending year:	2010		
CALCULATE	MAIN MENU		

Farm-gate price of aquaculture Seafood in World

Year	Culture production (mt)	Farm-gate prices of culture production (USD/kg)
1980	4,705,883	
1981	5,243,003	
1982	5,671,572	
1983	6,223,346	
1984	6,944,478	1.4
1985	8,021,908	1.4
1986	9,164,001	1.6
1987	10,565,565	1.7
1988	11,681,842	1.8
1989	12,315,315	1.8

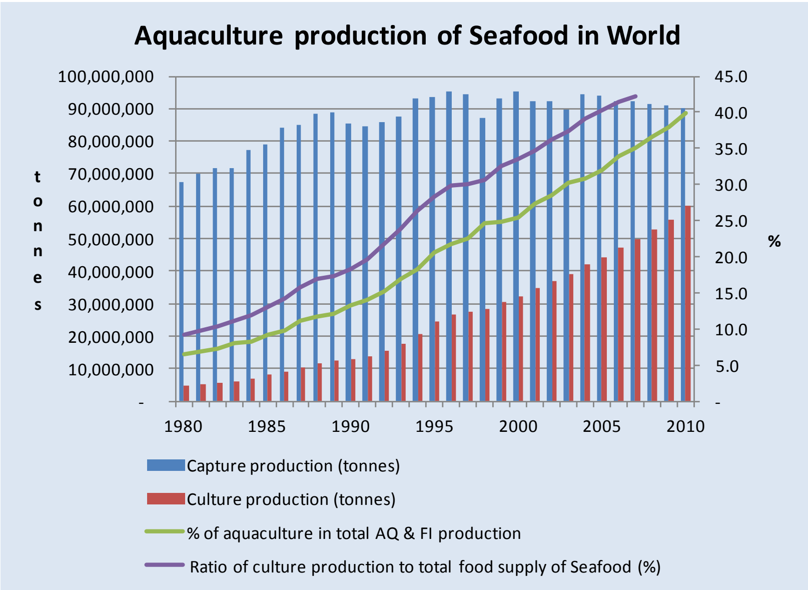


Figures in an indicator template can be modified. Users can make changes on chart styles, data range, chart title, axis, etc. Every figure corresponds to a table. The titles of tables and figures correspond to the selected parameters. In order to avoid mistakes, tables are protected from modification by users. However, users can copy and paste them into new Excel files for modification.

Standardized indicator templates can be developed and published to provide easy access to such massive data. For example, Figure A3 is a popular graph to show the trend in aquaculture's contribution to world fish supply.[4] In the draft tool, by changing parameters in the selection menu, users can easily obtain similar graphs for a country, subregion, or region and for different disaggregate fish species. Users can also change the chart styles according to their preferences.

FIGURE A3

An example of trend analysis



Standardized indicator templates in the tool can also help statisticians or users monitor the quality of and detect abnormalities in their data. For example, when plotting the time trend of aquaculture production area in China over time, we noticed a sudden and large dip in the year of 2007, which may not be easy to spot by looking at the tables. We felt puzzled and did some research to find out that the change was caused by statistical adjustments.

After standardized indicator templates have been developed, sharing them with others will be a win–win process that not only benefits the public but also polishes the existing templates while inciting the development of new templates because of different perspectives, knowledge and expertise of various users. However, an effective mechanism is needed to facilitate this knowledge management process. We elaborate on this point in Section 3.

2.2.1 Basic structure and contents of the tool

Indicator templates in the draft tool are under two sections: Section I, on the socio-economic and environmental impacts of aquaculture; and Section II on the status and trend of aquaculture development.

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[4] A similar graph appears in *The State of World Fisheries and Aquaculture 2012* (Figure 1): www.fao.org/docrep/016/i2727e/i2727e00.htm.

Section I

The indicators and templates in Section I of the draft tool (i.e. the socio-economic and environmental impacts of aquaculture) are structured from the perspective of policy-makers and anyone who would like to understand the performance of aquaculture in terms of its benefits and costs to society, economy and environment.

In the subsection “Socio-economic condition”, users can obtain background information about a country or region through socio-economic indicators such as population and demographics, food security and nutrition status, health, and GDP per capita.

In the subsection “Environmental costs of aquaculture”, users can obtain information on various environmental costs of aquaculture, including uses of natural resources in aquaculture (land, water, wild stocks, etc.), impacts of aquaculture on surrounding water and ecosystem, and impacts of aquaculture on biosecurity.

The subsection “Benefits vs costs” contains information on the productivity or efficiency of aquaculture in the utilization of various resources (natural, ecological, etc.).

The information provided in these subsections can help policy-makers understand the status and trend of aquaculture’s benefits and costs from different dimensions (socio-economic or environmental), in different scopes (country or region), and at different scales (individual species or fish as a whole). Such information can facilitate decision-making on resource allocations within aquaculture and between aquaculture and other sectors.

Section II

The indicators and templates in Section II (i.e. Status and trend of aquaculture development) are structured primarily from a production-chain perspective.

The section starts with fish supply, demand and trade and includes the following subsections:

- “Consumption & demand”, which includes indicators and templates on fish consumption.
- “Production & supply”, which includes indicators and templates on fish supply.
- “Commodities & trade” and “Bilateral trade”, which include indicators and templates on trade.
- “Food Balance Sheet”, which serves as a summary of the previous four subsections and includes indicators and templates for fish supply and utilization.

The subsections related to resource utilization in aquaculture include:

- “Labour”, which provides information on the use of human resources in aquaculture.
- “Land”, “Water”, “Feed” and “Seed”, which provide information on the use of natural resources in aquaculture.

Finally, the subsection “Projection” provides information on aquaculture’s future prospects, which includes:

- “Fish production projection”, which provides information on the future prospects of aquaculture production.
- “Future fish demand-supply gaps”, which provides information of potential gaps between fish supply and demand under different scenarios.

Templates can also be developed based on specific thematic topics, e.g.:

- Subsection “Price” includes indicators and templates on price variables in aquaculture.
- Subsection “Productivity” includes indicators and templates on productivity or efficiency of production and resource utilization in aquaculture.

2.2.2 Developing indicator templates

Indicator templates based on simple analysis

Simple analyses in the tool primarily include:

- comparison over time,
- cross-country comparison,
- cross-species comparison,
- cross-product comparison.

Standardized tables and graphs have been developed based on such comparisons, which can be utilized to prepare presentations, factsheets, policy briefs, technical papers, etc.

Such straightforward templates do not usually need to be associated with papers, reports or other supporting documents. They can be developed based on any data available and improved through “improving by using” processes.

Indicator templates based on more advanced analysis

One example of more advanced analysis is the “Global & regional overviews” in Template 6 in Section 4.4.1 (Table A2.1): “Contribution to food and nutrition intake (FAO Food Balance Sheet)”. This template contains a bubble chart that illustrates the relationship between countries’ per capita food or nutrient intake and the proportion of a species in it.

In that template, selecting the Indicator as “Per capita protein”, the Species as “Fish”, the Benchmark species as “Animal products”, and the Year as “2007” will result in the bubble chart in Figure A4.[5] The chart indicates that countries with relatively high per capita animal protein intake (mostly countries in developed regions) tend to have a relatively low fish share in animal protein intake. Therefore, generally speaking, fish are necessary goods for the poor and luxury goods for the rich.

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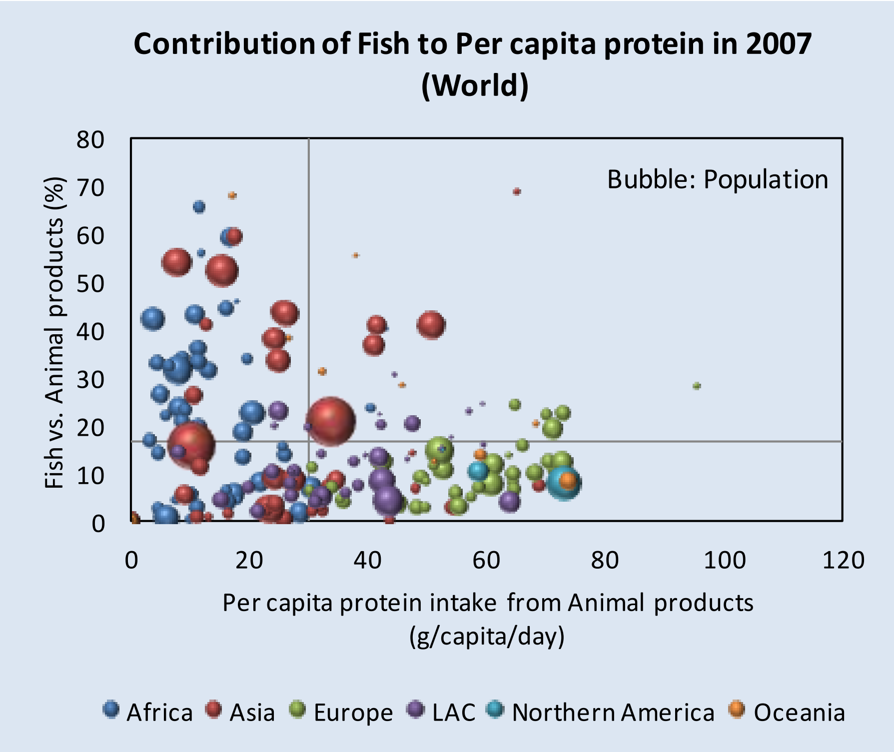
[5] Similar bubble charts for the situations in each region are also available in the template; as are charts for different indicators and species.

FIGURE A4

An example of correlation analysis



Another example of more advanced analysis is the "Food supply & utilization: Trend" in Template 56 in Section 4.5.5 (Table A9). The template contains a table and a chart that summarize the situation of fish supply and utilization in a country or area (Figure A5).

With a few clicks on the selection menu, users can obtain an overview of the supply and utilization of a fish species in a country or a country group.[6] Users can learn how much fish came from aquaculture (in terms of both weight and percentage), how much from capture fisheries, and, if the country has a positive net import, how much from net import. They can also find out how much fish was used for food, how much for feed, how much for other non-food purposes, and if the country has a positive net export, how much for net export. The chart would enable users to see the trend of such supply and utilization patterns and help them appreciate the situation more intuitively. A detailed table is also available in the template to provide more information on fish supply and utilization.

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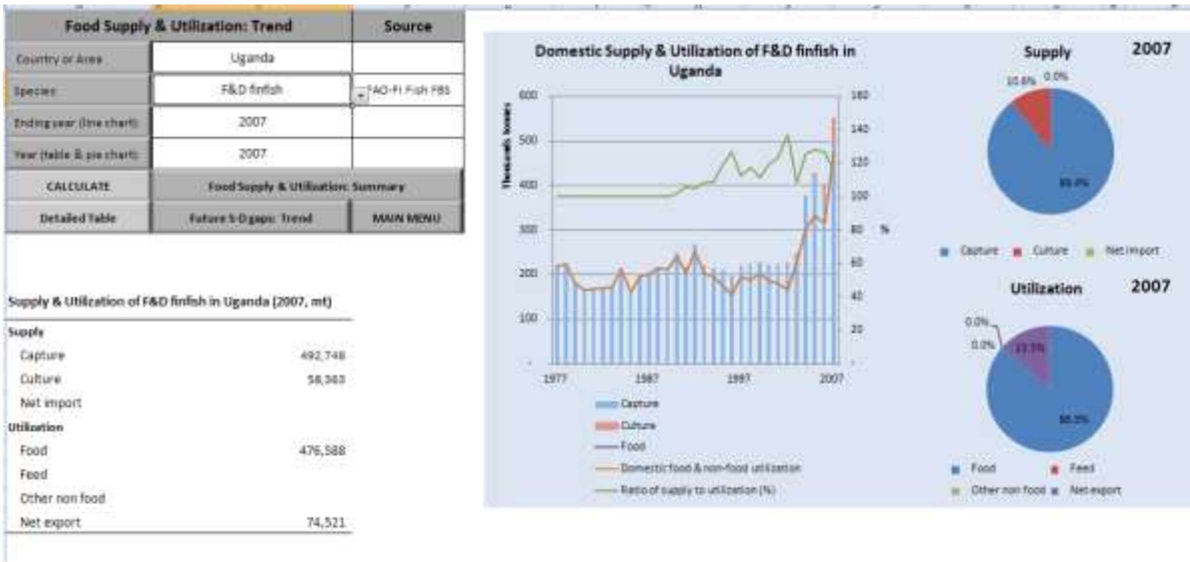
[6] The template also includes a few non-fish species.

FIGURE A5

Fish supply and utilization trend analysis



Templates for more advanced analysis are usually developed based on specific issues or studies in the literature. Tables and graphs available in the literature are usually specifically related to one or a few countries or regions, whereas the tool can help standardize such tables and graphs for as many countries and regions as data availability would allow.

Where available, relevant publications (factsheets, policy briefs, technical reports, journal articles, etc.) can be used as supporting materials to enrich templates based on more advanced analysis with contextual information. However, this is not essential – with some notes added to explain the contents, such templates usually can become self-explanatory.

Indicator templates based on complicated analysis

The “Future supply-demand gaps: trend” in Template 68 in Section 4.5.9 (Table A13) represents an example of templates based on complicated analysis.

As indicated in Figure A6, the template shows expected future fish demand, expected future fish supply from aquaculture and capture fisheries respectively, and the gaps between the demand and supply over time.

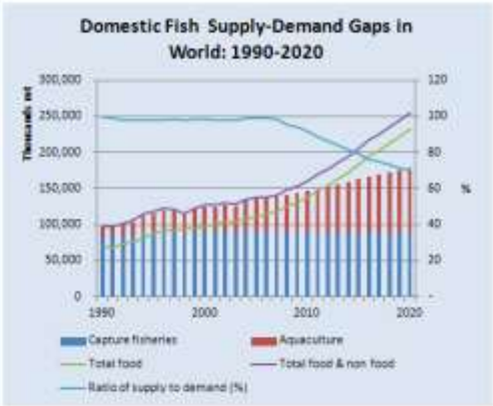
These results are based on an ongoing study in FAO/FI on estimating future fish demand and supply. The estimations were conducted for individual countries and species; estimated results for country groups and fish as a whole were obtained from aggregation. Figure A6 shows the situation of fish supply and demand gaps for the world, but users can easily obtain the results for individual countries and/or species.

FIGURE A6

Projections of future fish supply and demand

Future supply-demand gaps: Trend

Select country and species		Parameters	Enter alternative parameters	Default parameters (both pop. & income growth)	Baseline year
Country or Area:	World	Capture production APR (%):		0.0	2010
Species:	Fish	Culture production APR (%):		4.4	2010
Projection year:	2020	Population APR (%):		1.1	2010
CALCULATE	Future S-D gap: Summary	Total nonfood demand APR (%):		0.0	2007
Detailed table	Supply & Utilization: Trend	Per capita GDP ARP (%):		4.0	2010
MAIN MENU		Income elasticity:		1.1	2007



Domestic Fish Supply-Demand Gap in World in 2020

Indicators	Baseline year: 2007	Projection year: 2020
Supply-Demand gap		
Supply minus demand (mt)	-2,197,579	-75,872,218
Ratio of supply to demand (%)	98	70
Aquaculture growth during 2007-2020		
Expected APR (%)		4.8
Required APR (%)*		9.7

*Required APR in order to maintain the Supply-Demand gap (mt) at the baseline level.

In addition to the results based on default parameters used in the study, the template also allows users to obtain projections based on different parameters. This feature greatly expands the scope of the estimation exercise.

To be user friendly, templates based on complicated analysis usually need to be supported by certain publications. Conversely, such templates can serve as supporting materials (e.g. electronic appendix) for the publications. Such integration would lead to a win–win situation to facilitate information generation.

2.2.3 Updating indicator templates

Initial development of indicator templates in the draft WAPI tool is a time-consuming process requiring a great deal of effort. However, once developed, updating templates is relatively easy: Replacing or appending new data in the data templates would automatically update all the tables and graphs related to the data, and hence lead to new inferences, policy and management advice for the sector.

3. WAY FORWARD: STRATEGY AND ACTION PLANS

Issues, methods, data and people are four pillars that support assessment and monitoring of aquaculture sector performance. Issues are “menus” that determine what information to generate. Methods are “recipes” that provide guidance on how to generate the information. Data are “ingredients” that the information is derived from. People (i.e. human resources and capacity) are “cooks” responsible for putting things together to generate the information and provide guidance on how to use it.

Albeit still a prototype that entails many improvements, the draft WAPI tool has potential to become an effective way to integrate the four pillars for advancing assessment and monitoring of aquaculture sector performance. However, joint efforts from various stakeholders and experts are needed to sustain it. Sharing information and contributing to its generation, only in this way can the tool become a sustainable public good.

Looking forward, the draft WAPI tool can be improved, enriched and expanded in various ways:

- More tables and figures can be added to existing templates based on further analysis of the data already included in the tool.
- More data can be included in the tool to enrich the templates.
- More templates can be developed based on new data, method or issues.

This would be a long-term, continuing and improving-by-using process that entails coordinated efforts from many people. Professionals always need to utilize data to generate tables and graphs. The tool provides a way for them to capitalize their sporadic efforts into standardized templates for convenient use not only by themselves but also by others.

A strategy and action plans are needed to facilitate the development of this public good. Some thoughts in this regard are as follows:

- In principle, the tool should be an open-access instrument for the public.
- Templates in the draft tool are based primarily on publically available official data and statistics. Efforts should be exerted to broaden the data sources of the tool. Specific actions include:
  - Identifying regular or ad hoc official statistics sources that can be used to develop standardized templates. Regional databases (e.g. EUROSTAT) and national statistics yearbooks have plenty of potential to be exploited.
  - Identifying historical surveys and case studies that contain large quantity of data and exploring ways to develop standardized templates based on them.
  - Exploring ways to integrate template development into ongoing or potential surveys or case studies.
- The draft tool developed by FAO/FI can be used as a focal point to seek collaborations from partners or experts for improving existing templates and/or developing new templates.
  - Potential partners include international or regional organizations, research institutes, universities, national governments, among others.
  - Ideally, a template should be developed and maintained by experts who will use it the most frequently.
  - New templates can be part of the tool or independent modules linked to the tool.
  - FAO can provide technical assistance to facilitate template development.
  - FAO can provide a platform to facilitate distribution of templates.

- The current prototype is an α-version of the tool for internal test within FAO and with partners. After improvement, a β-version of the tool can be placed on the internet to gather comments and suggestions from broader audience and attract potential collaborations.
  - The FAO/FI website can be the main venue.
  - A Wikipedia page can also be developed to promote the tool.
  - Besides being an integrated part of the tool, different components or templates in the tool can be distributed separately to improve accessibility.
  - Downloading the tool or its templates from the internet is free of charge, but registration is required in order to gather information on potential users.
  - An online survey can be used to solicit feedbacks and collaborations.
  - Social media such as Google Group or LinkedIn can be established to facilitate collaborations.
  - A section in the website can be devoted to publishing templates developed and shared by individual experts.
- Based on the comments, suggestions and collaborations on the β-version, templates in the tool can be improved and released as formal information products when the following conditions are met:
  - Templates are developed, reviewed and tested thoroughly and rigorously.
  - Human and financial resources for maintaining and updating the tool are ensured.
- The tool will only become alive when being used by people. Frequent uses with feedbacks and subsequent improvements will establish the integrity of the tool. Actions to facilitate the use of the tool include:
  - Link templates in the tool to existing publications (factsheets, policy briefs, technical reports, journal papers, etc.) or produce new publications to support the templates.
  - Use the tool to produce standardized tables of core indicators on aquaculture performance.
    - Something similar to World Development Indicators http://data.worldbank.org/data-catalog/world-development-indicators
    - Such tables can be used to enrich other information products such as the National Aquaculture Sector Overview (NASO) www.fao.org/fishery/collection/naso/en
  - Develop issue-based modules that are intended to solve specific policy or sector management issues.
- There are several technical issues to consider:
  - The tool becomes slower as more data are included in the tool. More efficient Excel codes may be needed.
  - Should the tool be Excel-based or web-based? We think that Excel-based templates are more appropriate for the tool to be a shareware for expert users. Some simpler templates most wanted by non-expert users can be developed into web-based instruments.

4. Contents in the prototype WAPI tool

4.1 Front Page

The tool starts with a front page where a brief introduction of the tool is given.

On the top of the Front Page there are two buttons: one leads to a User's Guide; the other leads to the Main Menu.

4.2 User's Guide

A brief User's Guide is provided to help users set up the tool properly and give tips on how to use the tool.

4.3 Main Menu

The Main Menu is essentially a table of contents for the tool. It provides an overview of the various templates included in the tool.

A number of templates have been developed in the prototype tool. Most of them are based on FAO statistics on fish production, consumption and trade.

The templates belong to two sections. Section I includes indicators of the socio-economic and environmental impacts of aquaculture. Section II includes indicators of the status and trend of aquaculture development.

Some indicators may appear in both sections, but they are viewed from different perspectives. For example, employment in Section I is viewed as a contribution of aquaculture to poverty alleviation, while in Section II it is viewed as a cost of production.

4.4 Section I: Socio-economic and environmental impacts of aquaculture

Section I includes indicators on the socio-economic and environmental impacts of aquaculture, which contains three parts: aquaculture's socio-economic contributions as its benefits; aquaculture's environmental impacts as its costs; and productivity or efficiency of aquaculture's use of natural or ecological resources as indicators of trade-offs between its benefits and costs.

Conceptually, as most of aquaculture socio-economic impacts are positive, we deem aquaculture's socio-economic impacts as its benefits. Aquaculture would certainly have negative socio-economic impacts, which will be accounted as negative benefits.

Similarly, we deem the environmental impacts of aquaculture as its costs because most of its environmental impacts are negative.

Productivity indicators (such as land productivity and labour productivity) measure the benefits generated by aquaculture through using a unit of resources. Efficiency indicators (such as feed efficiency and energy efficiency) measure the costs of aquaculture for generating a unit of benefit. Such indicators measure trade-offs between the benefits and costs of aquaculture.

4.4.1 Socio-economic contributions of aquaculture

Summary of socio-economic contribution of aquaculture

A summary template is provided to present the core indicators of aquaculture's socio-economic contribution in a country or area. In this template, users are allowed to select a country (or area) of interest together with a benchmark country or area to which the selected country would be compared to.

For some indicators in this template such as aquaculture's contribution to protein intake, users can select different levels of species aggregate (i.e. fish, seafood, and seafood and aquatic plants). The definitions of these species groups will appear in a comment box when the user places the mouse cursor on the selection cell.

The summary template includes a number of indicator groups, such as population and demographics, food and nutrition status, contribution to per capita protein intake, and contribution to GDP.

Each indicator group contains one or more indicators that are related to a specific aspect. Some indicators may appear in different groups. For example, the indicator "Share of female in population" is included under "Population & demographics" and "Gender".

Placing the mouse cursor to an indicator or indicator group cell will show a comment box that contains information on the indicator such as the sources of data. Clicking an indicator or indicator group that is underscored would lead the user to templates that give more detailed information on the indicator or indicator group.

Socio-economic conditions

Table A1 summarizes the templates for assessing and monitoring the socio-economic conditions of countries or areas.

Socio-economic contributions of aquaculture

Table A2.1 summarizes the templates for assessing and monitoring aquaculture's contribution to food and nutrition security.

Table A2.2 summarizes the templates for assessing and monitoring aquaculture's economic performance.

Table A2.3 summarizes the templates for assessing and monitoring aquaculture's social performance.

4.4.2 Environmental costs of aquaculture

Tables A3.1–A3.4 summarize the templates for assessing and monitoring the environmental costs of aquaculture.

As quantitative data on the environmental impacts of aquaculture are generally lacking, many indicators for measuring the environmental costs of aquaculture are difficult to be quantified. Thus, no summary table on aquaculture's environmental costs is developed.

Except for use of land and use of feed and feed ingredients, most contents or templates related to the environmental costs simply present data or indicators obtained from the Global Aquaculture Performance Index (GAPI) website (http://web.uvic.ca/~gapi/index.html).

4.4.3 Benefits vs costs

Tables A4.1 and A4.2 summarize the templates for assessing and monitoring the trade-offs between the benefits and costs of aquaculture.

Indicators of productivity or efficiency in resource utilization in aquaculture are partial measures of tradeoffs between the benefits and costs of aquaculture. A few templates on productivity or efficiency of utilization of natural, human and other resources were developed. Data limitations do not allow us to do much on these templates. Most of these templates contain indicators that measure only one or a few dimensions of tradeoffs among various impacts of aquaculture.

One exception is the template on “GAPI scores (unit impact)”, which measures the net environmental impact of mariculture of a number of marine finfish species. Similar indices can be constructed in the future when the tool is populated more information.

4.5 Section II: Indicators of status and trends in aquaculture development

Section II includes indicators of the status and trend of aquaculture development, which can be used for policy-making or sector management. Indicators included in Section I may also appear in Section II, but they are viewed from different perspective. For example, the “Contribution to food supply” in Section I and the “% of aquaculture in total fish production” in Section II are actually the same template in different names.

4.5.1 Consumption and demand

Tables A5 summarizes the templates on fish consumption and demand.

4.5.2 Production and supply

Tables A6.1 and A6.2 summarize the templates for fish production and supply.

4.5.3 Commodities and trade (FAO FishStat data)

Table A7 summarizes the templates on fish commodities and trade developed based on data from FAO FishStat.

4.5.4 Bilateral trade (UN Comtrade data)

Table A8 summarizes the templates on bilateral fish trade developed based on data from UN Comtrade.

4.5.5 Food balance sheet

Table A9 summarizes the templates on fish commodities and trade developed based on data from FAO FishStat.

4.5.6 Labour

Table A10 summarizes the templates on labour use in aquaculture.

4.5.7 Land

Table A11 summarizes the templates on land use in aquaculture.

4.5.8 Feed

Table A12 summarizes the templates on feed use in aquaculture.

4.5.9 Projection

Table A13 summarizes the templates on supply and demand projections in aquaculture.

4.5.10 Prices

Table A14 summarizes the templates on the prices of fish.

4.5.11 Productivity

Table A15 summarizes the templates on productivity of resource utilization in aquaculture.

TABLE A1

WAPI templates on socio-economic conditions

Templates	Indicators included	Data sources utilized	Notes
(1) Population & demographics	▪ Population (#) ▪ Share of urban population (%) ▪ Total dependency ratio (%) ▪ Share of female in population (%)	▪ UN World Urban Prospects (2011 rev.) UN World Pop. Prospects (2012 rev.)	▪ Much more information from UN Population Division is yet to be included.
(2) Food & nutrition status	▪ Minimum dietary energy requirement (Kcal/person/day) ▪ Ratio of undernourished population (%) ▪ Share of food aid in total consumption (%) ▪ Share of food in household consumption (%)	▪ FAO Statistics Division ▪ FAO Statistics Household Survey Database	▪ Much more information on Food Security Status from FAO Statistics Division is yet to be included.
(3) Health	▪ Life expectancy at birth (year)	▪ World Bank, WDI	
(4) GDP per capita	▪ GDP per capita (current US$) ▪ GDP per capita (PPP)	▪ IMF, WEO Database	▪ Other indicators of GDP per capita are available in IMF WEO Database and in World Bank WDI.

TABLE A2.1

WAPI templates on aquaculture's contribution to food security and nutrition

Templates	Indicators included	Data sources utilized	Notes
(5) Contribution to food supply	▪ Capture production (tonnes) ▪ Culture production (tonnes) ▪ Total food supply of aquatic products (tonnes) ▪ Share of aquaculture in total AQ & FI production (%) ▪ Ratio of culture production to total food supply of aquatic products (%)	▪ FAO FishStat ▪ FAO/FI, Fish Food Balance Sheet	
(6) Contribution to food and nutrition intake (FAO Food Balance Sheet Data)	▪ Per capita food intake (kg per year) ▪ Per capita protein intake (g per day) ▪ Per capita fat intake (g per day) ▪ Per capita dietary energy intake (Kcal per day) ▪ Ratio of a species in per capita total food/protein/fat/energy intake (%) ▪ Ratio of a species in per capita animal food/protein/fat/energy intake (%)	▪ FAO/FI, Fish Food Balance Sheet ▪ FAOSTAT, Food Balance Sheet	▪ Non-fish species included in the templates
(7) Contribution to nutrition (FAO/ INFOOD data)	▪ Macronutrient contents (g) ▪ Water content (g) ▪ Share of protein in dry matter (%) ▪ Share of fat in dry matter (%) ▪ Share of carbohydrate in dry matter (%) ▪ Share of ash in dry matter (%) ▪ Fatty acid contents (g) ▪ Share of fatty acid in dry matter (g) ▪ Vitamin contents (mg or mcg) ▪ Mineral contents (mg or mcg)	▪ FAO/INFOODS Food Composition Database for Biodiversity (Version 2.0)	▪ More detailed data on fatty acid contents in FAO/INFOODS database are yet to be included. ▪ Data on non-fish products in FAO/INFOODS database are yet to be included. ▪ Data in USDA National Nutrient Database for Standard Reference are yet to be included. ▪ National Institute of Nutrition and Seafood Research (NIFES) in Norway is a potential collaborator.

TABLE A2.2

WAPI templates on the economic benefits of aquaculture

Templates	Indicators included	Data sources utilized	Notes
(8) Contribution to value addition and GDP	▪ Value addition of AQ & FI sector and subsectors (LCU) ▪ Share of value addition of AQ & FI sector or subsectors to GDP (%) ▪ Share of AQ & FI sector and subsectors to agricultural GDP (%) ▪ Share of AQ & FI subsectors to total value addition of the AQ & FI sector (%)	▪ China Fishery Statistics Yearbook	▪ Including only one country (China). ▪ The World Bank publication *The Hidden Harvests: the global contribution of capture fisheries* compiles plenty information on contribution of AQ & FI (mainly fisheries) to GDP. ▪ The Asian Development Bank publication "Fisheries in the Economies of the Pacific Island Countries and Territories" contains plenty information on contribution of AQ & FI (mainly fisheries) to GDP in Pacific Island countries and territories.
(9) Contribution to foreign exchange	▪ Export value of fish & fisheries products (US$) ▪ Import value of fish & fisheries products (US$) ▪ Net export value of fish & fisheries products (US$) ▪ Share of fish & fisheries products in total export value of all products (%) ▪ Share of fish & fisheries products in total import value of all products (%)	▪ UN Comtrade Database	▪ Aggregate fish & fisheries product groups presented in the template including: Fish & Fisheries products, Finfish, Shellfish, Meal & oil, and Aquatic plant. ▪ More disaggregate data are available in UN Comtrade Database.

TABLE A2.3

WAPI templates on the social benefits of aquaculture

Templates	Indicators included	Data sources utilized	Notes
(10) Contribution to employment	▪ Number of full-time equivalent jobs in AQ & FI sector or subsectors (#) ▪ Ratio of employment in AQ & FI to agricultural labour force (%) ▪ Ratio of employment in AQ & FI to total labour force (%) ▪ Share of employment in AQ & FI subsectors to total employment in AQ & FI (%)	▪ China Fishery Statistics Yearbook ▪ Data on economic active population in FAOSTAT	▪ Including only one country (China). ▪ FAO/FI has been compiled data on employment in aquaculture and fisheries. ▪ Some statistics published in SOFIA.
(11) Contribution to labour income	▪ Average annual earnings of working household members in AQ & FI sector (LCU)	▪ China Fishery Statistics Yearbook	▪ Including only one country (China). ▪ Detailed household survey data available in China Fishery Statistics Yearbook.
(12) Gender	▪ Number of female in population (#) ▪ Share of females in population (%) ▪ Share of female in labour force (%) ▪ Share of female in agriculture labour force (%) ▪ No. of female worker in AQ & FI (#) ▪ Share of female in AQ & FI workers (%)	▪ UN World Pop. Prospects (2012 rev.) ▪ Data on economic active population in FAOSTAT ▪ China Fishery Statistics Yearbook	▪ Indicators on female employment in AQ & FI are quantified for only one country (i.e. China).

TABLE A3.1

WAPI templates on the environmental costs of aquaculture (land and water)

Templates	Indicators included	Data sources utilized	Notes
(13) Use of land	▪ Aquaculture production area (ha) ▪ Ratio of aquaculture production area to inland water surface (%) ▪ Ratio of aquaculture production area to agriculture area (%) ▪ Ratio of aquaculture production area to country area (%)	▪ China Fishery Statistic Yearbook ▪ Data on land resources in FAOSTAT	▪ Including only one country (China). ▪ FAO/FI has been compiling data on land use in aquaculture, which are not systematically published because of concerns over data quality. ▪ More data on land use in aquaculture can be found in WorldFish publication "Blue Frontiers: managing the environmental costs of aquaculture.
(14) Use of water			▪ Because of lack of data, no templates were developed for use of water in aquaculture. ▪ A study initiated by FAO/FI has attempted to measure use of water in aquaculture. ▪ An ongoing project in FAO/FI is trying to compile data on use of water or water surface in aquaculture and fisheries.

TABLE A3.2

WAPI templates on the environmental costs of aquaculture (seed, feed and energy)

Templates		Indicators included	Data sources utilized	Notes
(15)	Use of wild seed stocks	▪ No. of individuals removed from the wild (#) ▪ Total weight removed from the wild (kg) ▪ Loss of future biomass due to capture-based aquaculture (kg)	▪ GAPI, Capture Based Aquaculture (CAP) Data & Calculations	▪ Including only marine finfish species. ▪ There are ongoing efforts in FAO/FI to compile data on aquatic genetic resources for the publication of State of World Aquatic Genetic Resources.
(16)	Use of feed & feed ingredients	▪ Use of feed (tonnes) ▪ Use of fishmeal (tonnes) ▪ Use of fish oil (tonnes)	▪ Based on various FAO publications on aquafeed.	▪ Including only the entire world. ▪ More data on feed use in aquaculture are available in FAO publications and other literature.
(17)	Use of ecological energy	▪ Proportion of feed components from different sources (%) ▪ Feed conversion ratios (#) ▪ Use of feed components (tonnes) ▪ Trophic level of feed components (#) ▪ Net primary productivity (NPP) of feed components (#)) ▪ Cumulative ecological energy score (ECOE) (#) ▪ Normalized ecological energy score (#)	▪ GAPI, Ecological Energy (ECOE) Data & Calculations	▪ Including only marine finfish species.
(18)	Use of industrial energy	▪ Production quantity (tonnes) ▪ Proportion of feed components (%) ▪ Knife coefficient (megajoules/tonne) ▪ Energy of individual components (megajoules/tonne) ▪ Total energy of feed components (megajoules/tonne) ▪ Total energy of production systems (megajoules/tonnes) ▪ Food Conversion Ratio (FCR) ▪ Amount of feed use (tonnes) ▪ Cumulative Industrial Energy (INDE) score ▪ Normalized Industrial Energy (INDE) score	▪ GAPI, Industrial Energy (INDE) Data & Calculations	▪ Including only marine finfish species.

TABLE A3.3

WAPI templates on the environmental costs of aquaculture (pollution)

Templates	Indicators included	Data sources utilized	Notes
(19) Biochemical oxygen demand (BOD)	▪ Production quantity (tonnes) ▪ Cumulative BOD score	▪ GAPI, Biochemical Oxygen Demand (BOD) Data & Calculations	▪ Including only marine finfish species.
(20) Antibiotics pollution	▪ Production quantity (tonnes) ▪ Amount of antibiotics used (kg) ▪ WHO-OIE scores for antibiotics ▪ Cumulative antibiotics scores	▪ GAPI, Antibiotics (ANTI) Data and Calculations	▪ Including only marine finfish species.
(21) Parasiticides pollution	▪ Production quantity (tonnes) ▪ Amount of parasiticides used (kg) ▪ LC50 (mg/L): Lethal concentration of a chemical in water that kills 50% of the test animals in a given time (represents the organisms most harmed by each substance. ▪ Persistence (half-life): Residency time of a chemical in the environment measured by its half-life in that environment. ▪ Cumulative parasiticides scores	▪ GAPI, Parasiticides (PARA) Data & Calculations	▪ Including only marine finfish species.
(22) Copper pollution	▪ Production quantity (tonnes) ▪ Proportion Using Copper-Based antifoulants (%) ▪ Cumulative copper (COP) scores	▪ GAPI, Antifoulants (Copper-COP) Data & Calculations	▪ Including only marine finfish species.

TABLE A3.4

WAPI templates on the environmental costs of aquaculture (biodiversity and biosecurity)

Templates	Indicators included	Data sources utilized	Notes
(23) Escapes	▪ Production quantity (tonnes) ▪ Escape ratio (# of escapes / tonne of production) ▪ Proportion of production in sea cage (%) ▪ # of escapes ▪ GAPI invasiveness score ▪ http://web.uvic.ca/~gapi/explore-gapi/esc.html ▪ Cumulative Escape (ESC) score	▪ GAPI, Escapes (ESC) Data & Calculations	▪ Including only marine finfish species.
(24) Diseases	▪ Production quantity (tonnes) ▪ Proportion of production loss due to disease (%) ▪ Production loss due to diseases (tonnes) ▪ Pathogenicity (%): relative proportion of total production losses that is attributed to the pathogen in question. ▪ Pathogen Specific Production Loss (tonnes) ▪ Proportion of Susceptible Fish Biomass in Ecosystem (%) ▪ Pathogen-Specific Wild Loss (tonnes) ▪ Cumulative Pathogen (PATH) score	▪ GAPI, Pathogen (PATH) Data & Calculations	▪ Including only marine finfish species.

TABLE A3.5

WAPI templates on the environmental costs of aquaculture (total impact)

Templates	Indicators included	Data sources utilized	Notes
(25) GAPI scores (total impact)	▪ GAPI (total impact): Summarizing indicator ▪ CAP: Impact on wild species ▪ FEED: Feed sustainability ▪ INDE: Use of industrial energy ▪ ECOE: Use of ecological energy ▪ BOD: Biochemical oxygen demand ▪ ANTI: Antibiotics ▪ PARA: Parasiticides ▪ COP: Copper population ▪ ESC: Escapes ▪ PATH: Pathogens	▪ GAPI	▪ Including only marine finfish species.

TABLE A4.1

WAPI templates on benefits vs costs (labour, land and feed)

Templates	Indicators included	Data sources utilized	Notes
(26) Labour productivity	▪ Aquaculture production (tonnes) ▪ Aquaculture production value (thousand US$) ▪ Capture fisheries production (tonnes) ▪ Total fish production (tonnes) ▪ Number of full-time equivalent jobs (#) ▪ Aquaculture production quantity per job (tonnes/job) ▪ Capture fisheries production quantity per job (tonnes/job) ▪ AQ & FI production quantity per job (tonnes/job) ▪ Aquaculture production value per job (thousand US$/job) ▪ Capture fisheries production value per job (thousand US$/job) ▪ AQ & FI production value per job (thousand US$/job) ▪ Aquaculture value addition per job (thousand LCU/job) ▪ Capture fisheries value addition per job (thousand LCU/job) ▪ AQ & FI value addition per job (thousand LCU/job)	▪ FAO FishStat Plus ▪ China Fishery Statistic Yearbook	▪ Including only one country (China).
(27) Land productivity	▪ Aquaculture production (tonnes) ▪ Aquaculture production area (ha) ▪ Land productivity (tonnes/ha)	▪ FAO FishStat Plus ▪ China Fishery Statistic Yearbook	▪ Including only one country (China).
(28) Feed efficiency (measured by feed use)	▪ Aquaculture production (tonnes) ▪ Use of feed in aquaculture (tonnes) ▪ Use of fishmeal in aquaculture (tonnes) ▪ Use of fish oil in aquaculture (tonnes) ▪ Feed efficiency: Use of feed (tonnes) per tonne of aquaculture production ▪ Fishmeal efficiency: Use of fishmeal (tonnes) per tonne of aquaculture production ▪ Fish oil efficiency: Use of fish oil (tonnes) per tonne of aquaculture production	▪ FAO FishStat Plus ▪ Based on various FAO publications on aquafeed.	▪ Including only the entire world. ▪ Including several aggregate species groups: Fish, Freshwater finfish, Diadromous finfish, Freshwater & diadromous finfish, Marine finfish, and Crustacean.
(29) Feed efficiency (measured by NPP)	▪ Normalized Net Primary Productivity (NPP) score	▪ GAPI	▪ Including only marine finfish species.

TABLE A4.2

WAPI templates on benefits vs costs (energy, pollution, biodiversity and biosecurity)

<table>
<tr><th>Templates</th><th>Indicators included</th><th>Data sources utilized</th><th>Notes</th></tr>
<tr><td>(30) Energy efficiency</td><td>▪ Use of industrial energy (megajoules per tonne of production)</td><td rowspan="7">▪ GAPI</td><td rowspan="7">▪ Including only marine finfish species.</td></tr>
<tr><td>(31) BOD efficiency</td><td>▪ Biological oxygen demand (BOD score per tonne of production)</td></tr>
<tr><td>(32) Antibiotics efficiency</td><td>▪ Use of antibiotics (kg per tonne of production)</td></tr>
<tr><td>(33) Parasiticides efficiency</td><td>▪ Use of parasiticides (PARA score per tonne of production)</td></tr>
<tr><td>(34) Copper efficiency</td><td>▪ Proportion of production using copper-based anti-foulants (%)</td></tr>
<tr><td>(35) Escape efficiency</td><td>▪ Escape score per tonne of production</td></tr>
<tr><td>(36) Disease efficiency</td><td>▪ Proportion of production loss due to disease (%)</td></tr>
</table>

TABLE A4.3

WAPI templates on benefits vs costs (unit impacts)

Templates	Indicators included	Data sources utilized	Notes
(37) GAPI scores (unit impact)	▪ GAPI (normalized unit impact): Summarizing indicator ▪ CAP: Impact on wild species ▪ FEED: Feed sustainability ▪ INDE: Use of industrial energy ▪ ECOE: Use of ecological energy ▪ BOD: Biochemical oxygen demand ▪ ANTI: Antibiotics ▪ PARA: Parasiticides ▪ COP: Copper population ▪ ESC: Escapes ▪ PATH: Pathogens	▪ GAPI	▪ Including only marine finfish species.

TABLE A5

WAPI templates on fish consumption and demand

Templates	Indicators included	Data sources utilized	Notes
(38) Consumption	▪ Total consumption (tonne) ▪ Per capital consumption (kg/capita/year) ▪ Ratio of total consumption of a country or area to that of another country or area (%) ▪ Ratio of per capita consumption of a country or area to that of another country or area (%) ▪ Ratio of total consumption of a species to that of another species (%) ▪ Ratio of per capita consumption of a species to that of another species (%) ▪ APR of total consumption during a period (%) ▪ APR of per capita consumption during a period (%)	▪ FAO/FI, Fish Food Balance Sheet ▪ FAOSTAT, Food Balance Sheet	▪ Several non-fish species included.
(39) Demand growth	▪ Change in the demand of a country or area caused by its population growth (tonne) ▪ Change in the demand of a country or area caused by change in its per capita demand (tonne)	▪ FAO/FI, Fish Food Balance Sheet ▪ UN World Pop. Prospects (2012 rev.)	▪ Including only fish species.

TABLE A6.1

WAPI templates on fish production and supply (production quantity)

Templates	Indicators included	Data sources utilized	Notes
(40) AQ & FI production	▪ Quantity of aquaculture production (tonne) ▪ Farm-gate value of aquaculture production (thousand US$) ▪ Quantity of capture fisheries production (tonne) ▪ Ratio of aquaculture production quantity of a country or area to that of another country or area (%) ▪ Ratio of aquaculture production value of a country or area to that of another country or area (%) ▪ Ratio of capture fisheries production quantity of a country or area to that of another country or area (%) ▪ Ratio of aquaculture production quantity of a species to that of another species (%) ▪ Ratio of aquaculture production value of a species to that of another species (%) ▪ Ratio of capture fisheries production quantity of a species to that of another species (%) ▪ APR of aquaculture production quantity during a period (%) ▪ APR of aquaculture production value during a period (%) ▪ APR of capture fisheries production quantity during a period (%) ▪ Total food supply of aquatic products (tonne) ▪ Proportion of aquaculture in total AQ & FI production quantity (%) ▪ Ratio of aquaculture production quantity to total food supply of aquatic products (%)	▪ FAO FishStat ▪ FAO/FI, Fish Food Balance Sheet	▪ Include only aggregate aquatic species. ▪ More disaggregate fish production data are available in FAO FishStat.

TABLE A6.2

WAPI templates on fish production and supply (value, price, value Chain and diversification)

Templates	Indicators included	Data sources utilized	Notes
(41) Farm-gate value of AQ production	▪ Quantity of aquaculture production (tonnes) ▪ Farm-gate value of aquaculture production (thousand US$) ▪ Farm-gate price of aquaculture production (US$/kg) ▪ Ratio of farm-gate value of aquaculture production to GDP (%)	▪ FAO FishStat ▪ IMF, WEO Database	▪ Include only aggregate aquatic species. ▪ More disaggregate fish production data are available in FAO FishStat.
(42) Farm-gate price of AQ production	▪ Quantity of aquaculture production (tonnes) ▪ Farm-gate price of aquaculture production (US$/kg)	▪ FAO FishStat	▪ Include only aggregate aquatic species. ▪ More disaggregate fish production data are available in FAO FishStat.
(43) AQ & FI value chain	▪ Value addition of the AQ & FI sector and subsectors (LCU) ▪ Share of AQ & FI subsectors in the total value addition of the entire AQ & FI value chain (%)	▪ China Fishery Statistics Yearbook	▪ Including only one country (China)
(44) Species diversification in AQ production	▪ Production share (%) ▪ Specialization ratio (%) ▪ Entropy index ▪ Herfindahl index ▪ Various revealed comparative advantage (RCA) indices.	▪ FAO FishStat	▪ Under construction

TABLE A7

WAPI templates on fish commodities and trade (FAO FishStat)

Templates	Indicators included	Data sources utilized	Notes
(45) Trade summary	▪ Export quantity (tonnes) ▪ Export value (FOB, thousand US$) ▪ Export price (FOB, US$/kg) ▪ Import quantity (tonnes) ▪ Import value (CIF, thousand US$) ▪ Import price (CIF, US$/kg)	▪ FAO FishStat	▪ Include only aggregate aquatic species. ▪ Include only aggregate product groups. ▪ More disaggregate data available in FAO FishStat.
(46) Export	▪ Export quantity (tonnes) ▪ Export value (FOB, thousand US$) ▪ Ratio of export quantity of a country or area to that of another country or area (%) ▪ Ratio of export value (FOB) of a country or area to that of another country or area (%) ▪ Ratio of export quantity of a species to that of another species (%) ▪ Ratio of export value (FOB) of a species to that of another species (%) ▪ Ratio of export quantity of a product to that of another product (%) ▪ Ratio of export value (FOB) of a product to that of another product (%) ▪ APR of export quantity during a period (%) ▪ APR of export value (FOB) during a period (%)		
(47) Import	▪ Import quantity (tonnes) ▪ Import value (CIF, thousand US$) ▪ Ratio of Import quantity of a country or area to that of another country or area (%) ▪ Ratio of Import value (CIF) of a country or area to that of another country or area (%) ▪ Ratio of Import quantity of a species to that of another species (%) ▪ Ratio of Import value (CIF) of a species to that of another species (%) ▪ Ratio of Import quantity of a product to that of another product (%) ▪ Ratio of Import value (CIF) of a product to that of another product (%) ▪ APR of Import quantity during a period (%) ▪ APR of Import value (CIF) during a period (%)		

Templates	Indicators included	Data sources utilized	Notes
(48) Species and product diversification in fish trade	▪ Market share (%) ▪ Specialization ratio (%) ▪ Entropy index ▪ Herfindahl index ▪ Various revealed comparative advantage (RCA) indices.	▪ FAO FishStat ▪ UN Comtrade	▪ Under construction

TABLE A8

WAPI templates on bilateral fish trade (UN Comtrade)

Templates	Indicators included	Data sources utilized	Notes
(49) Trade value (CIF): summary	▪ Value of a country or area's export of fish & fisheries products to the world (CIF, thousand US$) ▪ Value of a country or area's import of fish & fisheries products from the world (CIF, thousand US$) ▪ Net export value (CIF, thousand US$) ▪ Share of fish & fisheries products in total export value (CIF) of all products ▪ Share of fish & fisheries products in total import value (CIF) of all products	▪ UN Comtrade	▪ Including only aggregate aquatic species. ▪ Including only aggregate product groups. ▪ Data on more disaggregate species or products are available in UN Comtrade.
(50) Export value (CIF): summary	▪ Value of a country or area's export to another country or area (CIF, thousand US$) ▪ Price of a country or area's export to another country or area (CIF, thousand US$) ▪ Share of a product in a country or area's total export of fish & fisheries products to another country (%) ▪ Share of a product in a country or area's total export of all products to another country		
(51) Export destination	▪ Value (CIF) of a country or area's export to another country or area (thousand US$) ▪ Share of a country or area's export to another country in its total export to the world (%) ▪ Change in the value (CIF) of a country or area's export to another country or area over time (thousand US$) ▪ APR of the value (CIF) of a country or area's export to another country or area during a period (%)		
(52) Import value (CIF): summary	▪ Value of a country or area's import from another country or area (CIF, thousand US$) ▪ Price of a country or area's import another country or area (CIF, thousand US$) ▪ Share of a product in a country or area's total import of fish & fisheries products from another country (%) ▪ Share of a product in a country or area's total import of all products from another country (%)		
(53) Import origin	▪ Value (CIF) of a country or area's import from another country or area (thousand US$) ▪ Share of a country or area's import from another country in its total import from the world (%) ▪ Change in the value (CIF) of a country or area's import from another country or area over time (thousand US$) ▪ APR of the value (CIF) of a country or area's import from another country or area during a period (%)		
(54) Trade prices	▪ Price (CIF) of a selected product traded between a selected exporter and a selected importer (US$/kg)		

TABLE A9

WAPI templates on Food Balance Sheet

<table>
<tr><th>Templates</th><th>Indicators included</th><th>Data sources utilized</th><th>Notes</th></tr>
<tr><td>(55) Food balance sheet variables</td><td>▪ Supply from domestic production (live weight, tonnes)
▪ Supply from import (live weight, tonnes)
▪ Supply from stock (live weight, tonnes)
▪ Utilization for food (live weight, tonnes)
▪ Utilization for feed (live weight, tonnes)
▪ Utilization for other non-food purposes (live weight, tonnes)
▪ Utilization for export (live weight, tonnes)</td><td rowspan="2">▪ FAO/FI, Fish Food Balance Sheet
▪ FAOSTAT, Food Balance Sheet</td><td rowspan="2">▪ Including non-aquatic species.
▪ Including only aggregate species groups.</td></tr>
<tr><td>(56) Food supply and utilization</td><td>▪ Supply from domestic production (live weight, tonnes)
▪ Supply from domestic production from culture (live weight, tonnes)
▪ Supply from domestic production from capture (live weight, tonnes)
▪ Supply from import (live weight, tonnes)
▪ Supply from stock (live weight, tonnes)
▪ Utilization for food (live weight, tonnes)
▪ Utilization for feed (live weight, tonnes)
▪ Utilization for other non-food purposes (live weight, tonnes)
▪ Utilization for export (live weight, tonnes)</td></tr>
</table>

TABLE A10

WAPI templates on labour use in aquaculture

Templates	Indicators included	Data sources utilized	Notes
(57) Composition of labour force	▪ Share of agriculture workers in labour force ▪ Share of female in labour force ▪ Share of female in agriculture labour force	▪ Data on economic active population in FAOSTAT	
(58) Employment in AQ & FI	▪ Same as Template 10		
(59) Labour productivity	▪ Same as Template 27		

TABLE A11

WAPI templates on land use in aquaculture

Templates	Indicators included	Data sources utilized	Notes
(60) Use of land resources in aquaculture	▪ Aquaculture production area (ha) ▪ Ratio of aquaculture production area to inland water surface (%) ▪ Ratio of aquaculture production area to agriculture area (%) ▪ Ratio of aquaculture production area to country area (%) ▪ Ratio of aquaculture production area for a species to total aquaculture production area (%) ▪ Aquaculture production (tonnes) ▪ Aquaculture production area (ha) ▪ Land productivity (tonnes/ha)	▪ China Fishery Statistic Yearbook ▪ Data on land resources in FAOSTAT	▪ Only including one country (China)

TABLE A12

WAPI templates on feed use in aquaculture

Templates	Indicators included	Data sources utilized	Notes
(61) Use of feed & feed ingredients	▪ Same as Template 16		
(62) Feed ingredients	▪ Use of fishmeal in aquaculture (tonnes) ▪ Use of fish oil in aquaculture (tonnes)	▪ Based on various FAO publications on aquafeed.	▪ Including only the entire world
(63) Fishmeal	▪ Quantity of world trade of ordinary fishmeal (tonnes) ▪ Quantity of world trade of fishmeal of offal (tonnes) ▪ Ratio of offal meal in the quantity of total world trade of fishmeal (%) ▪ Value of world trade of ordinary fishmeal (tonnes) ▪ Value of world trade of fishmeal from offal (tonnes) ▪ Ratio of offal meal in the value of total world trade of fishmeal (%) ▪ Price (CIF) of world trade of ordinary fishmeal (US$/tonnes) ▪ Price (CIF) of world trade of fishmeal from offal (US$/tonnes) ▪ Use of fish oil in aquaculture (tonnes)	▪ FAO FishStat	▪ Including only the entire world. ▪ Data on fishmeal trade are available in UN Comtrade.
(64) Use of ecological energy	▪ Same as Template 17		
(65) Feed efficiency (measured by feed use)	▪ Same as Template 28		
(66) Feed efficiency (measured by PPP)	▪ Same as Template 29		

TABLE A13

WAPI templates on projections of fish supply and demand

Templates	Indicators included	Data sources utilized	Notes
(67) Fish production projection	▪ Quantity of aquaculture production (tonnes) ▪ Changes in quantity of aquaculture production over time (tonnes) ▪ APR of aquaculture production during a period (%) ▪ Quantity of capture fisheries production (tonnes) ▪ Changes in quantity of capture fisheries production over time (tonnes) ▪ APR of capture fisheries production during a period (%)	▪ FAO FishStat	▪ Projections are based on linear extrapolations up to 2030.
(68) Future supply-demand gaps	▪ Projected future fish supply from aquaculture (tonnes) ▪ Projected future fish supply from capture fisheries (tonnes) ▪ Projected per capita fish demand (kg/year) ▪ Projected total fish demand (tonnes) ▪ Ratio of projected fish supply to projected fish demand (%) ▪ Excess fish supply or demand in the future (tonnes)	▪ FAO FishStat ▪ FAO/FI, Fish Food Balance Sheet	▪ Supply projections are linear extrapolations based on recent trends. ▪ Demand projections are based on a study conducted by FAO/FI. Parameters can be altered to provide different scenarios. ▪ Other forecasting models include the OECD-FAO Fish Model and the WB-IFPRI-FAO Fish 2030 Model.

TABLE A14

WAPI templates on prices of fish

Templates	Indicators included	Data sources utilized	Notes
(69) Farm-gate prices		▪ Same as Template 42.	
(70) Trade prices		▪ Same as Template 54.	

TABLE A15

WAPI templates on productivity of resource utilization in aquaculture

Templates	Indicators included	Data sources utilized	Notes
(71) Labour productivity		▪ Same as Template 26.	
(72) Land productivity		▪ Same as Template 27.	

Aquaculture is a fast-growing sector with complex environmental, economic and social impacts. Assessment and monitoring of such impacts is essential for stakeholders in both the public and private sectors to conduct evidence-based policy-making and/or sector management. However, the lack of information and knowledge (especially quantitative indicators) about aquaculture sector performance has been a global and perennial issue. The issue is especially critical for regions with a less developed aquaculture sector (e.g. Africa). Almost 30 experts from different countries attended the FAO Expert Workshop on Assessment and Monitoring of Aquaculture Sector Performance to discuss the methodologies and techniques of, and to share global, regional and national experiences in, assessing and monitoring the performance of aquaculture. The workshop included 28 presentations under six thematic topics by experts from various disciplines. A user-friendly tool called World Aquaculture Performance Indicators (WAPI) was presented at the workshop. Three working groups discussed issues related to the assessment and monitoring of aquaculture's social, economic and environmental performance. This report documents the information, knowledge and insights generated by the workshop.