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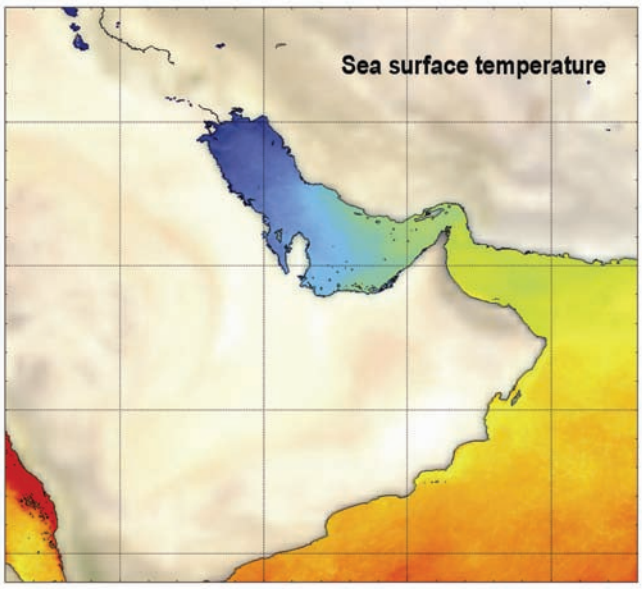
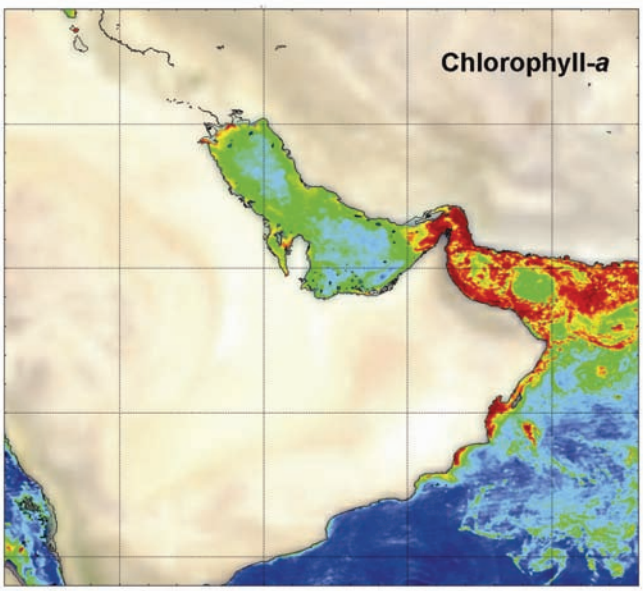
# REGIONAL COMMISSION FOR FISHERIES

**Report of the**

# FAO TECHNICAL WORKSHOP ON A SPATIAL PLANNING DEVELOPMENT PROGRAMME FOR MARINE CAPTURE FISHERIES AND AQUACULTURE

**Cairo, the Arab Republic of Egypt, 25–27 November 2012**



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**Cover illustrations**

Seasonal snapshots for March 2013 of sea surface temperature and chlorophyll-*a* in the RECOFI region from remote sensing imagery (courtesy of ACRI-ST using MODIS-Aqua data from NASA).

Sea surface temperature values range from 18°C (blue color) to 28°C (red color). Chlorophyll-*a* values range from 0.1 mg/m$^3$ (blue color) to 10 mg/m$^3$ (red color).

Knowledge of variations in such environmental parameters can help identify areas suitable for mariculture. Remote sensing data provide essential information for the spatial planning and management of aquaculture activities, as well as monitoring in the RECOFI region. Surface water temperatures control the distribution of many pelagic species important to the region, and chlorophyll-*a* densities provide a strong clue for marine fishers as to feed availability for lower-trophic-order marine species.

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Cairo, the Arab Republic of Egypt, 25–27 November 2012

FOOD AND AGRICULTURE ORGANIZATION OF THE UNITED NATIONS
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## PREPARATION OF THIS DOCUMENT

This document is the final report of the Regional Commission for Fisheries (RECOFI) Regional Technical Workshop on "A Spatial Planning Development Programme for Marine Capture Fisheries and Aquaculture", which was held from 25 to 27 November 2012 in Cairo, Egypt. It contains the three major outputs arising from the workshop: (i) the "RECOFI Spatial Planning Development Programme Questionnaire Survey Analysis Report"; (ii) the "Proposal for a Spatial Planning Development Programme for Marine Capture Fisheries and Aquaculture in RECOFI member countries"; and (iii) concept notes for pilot projects on marine fisheries and aquaculture.

This report was prepared by the Workshop Secretariat, José Aguilar-Manjarrez, Aquaculture Officer of the Aquaculture Branch (FIRA) of the FAO Fisheries and Aquaculture Department, and Geoffery J. Meaden, Patrick White and Peter Longdill, FAO consultants.

## ACKNOWLEDGEMENTS

Many thanks are due to the FAO Regional Office for the Near East and North Africa for the generous support and excellent hosting of the workshop. Special thanks are due to Hebatallah Fahmy, Programme Assistant of the FAO Regional Office for the Near East and North Africa, for her support in organizing the workshop, and to Fabio Carocci, Fishery Information Assistant, Marine and Inland Fisheries Branch of FAO, for his assistance in preparing the questionnaire survey form, the map presented in Annex 3 of Appendix 9, and for his comments on the concept notes on marine fisheries presented in this report.

**FAO/Regional Commission for Fisheries**. 2013.
*Report of the Regional Technical Workshop on a Spatial Planning Development Programme for Marine Capture Fisheries and Aquaculture. Cairo, the Arab Republic of Egypt, 25–27 November 2012*. FAO Fisheries and Aquaculture Report No. 1039. Rome. 127 pp.

## ABSTRACT

The latest session of the Regional Commission for Fisheries (RECOFI), held in Rome in May 2011, agreed to adopt an FAO/RECOFI joint Working Group on Aquaculture and Working Group on Fisheries Management regional spatial planning approach to marine capture fisheries and aquaculture for the RECOFI region, and, within available resources, to provide the necessary support for follow-up actions for the implementation of a regional strategy. The workshop, held in Cairo, Egypt (25–27 November 2012), was hosted by the FAO Regional Office for the Near East and North Africa. Twelve delegates participated, representing six RECOFI member countries (Bahrain, Iraq, Oman, Qatar, Saudi Arabia, and the United Arab Emirates) and FAO. The purpose of the workshop was to complete a "Spatial Planning Development Programme" to support a "Regional Strategy" in as much detail as possible, including preliminary budget estimates for the development of the capacity to use spatial tools in fisheries and aquaculture management and planning.

The significant outputs of the workshop were:

- Awareness and capacity building on spatial planning for marine capture fisheries and aquaculture.
- RECOFI Spatial Planning Development Programme for Marine Capture Fisheries and Aquaculture Questionnaire Survey Analysis Report.
- Proposal for a Spatial Planning Development Programme for Marine Capture Fisheries and Aquaculture.
- Concept notes for pilot projects on marine fisheries and aquaculture.

## CONTENTS

**APPENDIXES**

# ABBREVIATIONS AND ACRONYMS

| | |
|---|---|
| BCSR | Bahrain Centre for Studies and Research |
| CD | compact disc |
| CGIS | Centre for Geographic Information System in the State of Qatar |
| CHARM | Channel Habitat Atlas for Marine Resource Management |
| CPUE | catch per unit of effort |
| DBMS | database management system |
| DVD | digital video disc |
| EAA | ecosystem approach to aquaculture |
| EAF | ecosystem approach to fisheries |
| EEZ | exclusive economic zone |
| ESRI | Environmental Systems Research Institute |
| FAO | Food and Agriculture Organization of the United Nations |
| FIRA | Aquaculture Branch |
| FIRF | Marine and Inland Fisheries Branch |
| FOSS | Free and Open Source Software |
| GIS | geographic information systems |
| GISFish | Global Gateway to Geographic Information Systems, Remote Sensing and mapping for Fisheries and Aquaculture |
| GPS | global positioning system |
| IT | information technology |
| KISR | Kuwait Institute for Scientific Research |
| KML | Keyhole Markup Language |
| LiDAR | light detection and ranging |
| MERC | Marine Environment Research Centre |
| MIS | Fisheries Marine Information System |
| MOEW | Ministry of Environment and Water |
| MPA | marine protected area |
| MSP | marine spatial planning |
| NASO | National Aquaculture Sector Overview |
| NGO | non-governmental organization |
| RAIS | Regional Aquaculture Information System |
| RECOFI | Regional Commission for Fisheries |
| ROPME | Regional Organization for the Protection of the Marine Environment |
| SQL | System Query Language |
| SQU | Sultan Qaboos University |
| SST | sea surface temperature |
| SWLRI | Strategy for Water and Land Resources in Iraq |
| SWOT | strengths, weaknesses, opportunities and threats |
| TIN | triangulated irregular network |
| UNEP | United Nations Environment Programme |
| UNESCO | United Nations Educational, Scientific and Cultural Organization |
| USAID | United States Agency for International Development |
| VMS | vessel monitoring system |
| WAN | wide area network |
| WGA | RECOFI Working Group on Aquaculture |
| WGFM | RECOFI Working Group on Fisheries Management |
| WWW | World Wide Web |

# GLOSSARY

## SPATIAL TOOLS

**Geographic information systems (GIS).** An integrated collection of computer software and data used to view and manage information about geographic places, analyse spatial relationships, and model spatial processes. A GIS provides a framework for gathering and organizing spatial data and related information so that it can be displayed and analysed.[1]

**Global Positioning System (GPS).** A system of radio-emitting and -receiving satellites used for determining positions on the earth. The orbiting satellites transmit signals that allow a GPS receiver anywhere on earth to calculate its own location through trilateration. Developed and operated by the United States Department of Defense, the system is used in navigation, mapping, surveying, and other applications in which precise positioning is necessary.[1]

**Remote sensing.** Collecting and interpreting information about the environment and the surface of the earth from a distance, primarily by sensing radiation that is naturally emitted or reflected by the earth's surface or from the atmosphere, or by sensing signals transmitted from a device and reflected back to it. Examples of remote-sensing methods include aerial photography, radar and satellite imaging.[1, 2]

## FISHERIES AND AQUACULTURE

**Code of Conduct for Responsible Fisheries (the Code).** FAO-formulated code that sets out principles and international standards of behaviour for responsible aquaculture and fisheries practices with a view to ensuring the effective conservation, management and development of living aquatic resources, with due respect for the ecosystem and biodiversity.[6]

**Ecosystem approach to aquaculture (EAA).** The ecosystem approach to aquaculture is a strategic approach to development and management of the sector aiming to integrate aquaculture within the wider ecosystem such that it promotes sustainability of interlinked social-ecological systems. This is essentially applying ecosystem-based management as proposed by the Convention on Biological Diversity (UNEP/CBD/COP/5/23. Decision V/6, pp. 103–106) to aquaculture and also following the guidance provided by the Code (see above).[8]

**Ecosystem approach to fisheries (EAF).** An approach to fisheries management and development that strives to balance diverse societal objectives by taking into account the knowledge and uncertainties about biotic, abiotic and human components of ecosystems and their interactions and applying an integrated approach to fisheries within ecologically meaningful boundaries. The purpose of the EAF is to plan, develop and manage fisheries in a manner that addresses the multiple needs and desires of societies without jeopardizing the options for future generations to benefit from the full range of goods and services provided by marine ecosystems.[7]

**Mariculture.** Cultivation, management and harvesting of marine organisms in their natural habitat or in specially constructed rearing units, e.g. ponds, cages, pens, enclosures and tanks. For the purpose of FAO statistics, mariculture refers to cultivation of the end product in seawater even though earlier stages in the life cycle of the aquatic organisms concerned may be cultured in brackish water or freshwater.[4]

**Marine spatial planning (MSP).** A process of analysing and allocating parts of three-dimensional marine spaces to specific uses to achieve ecological, economic and social objectives that are usually specified through the political process; the MSP process usually results in a comprehensive plan or vision for a marine region. Marine spatial planning is an element of sea-use management.[5]

**Plan.** A roadmap for the implementation of a strategy, that is, to achieve its objectives and implement strategy instruments. It is time-bound, contains specific programmes and activities, and details the resources required to achieve them.[3]

**Programme.** Broadly speaking, a programme is an element of a plan.[3]

**Policy.** A broad vision for the sector, reflecting its directions, priorities and development goals at various levels, including provincial, national, regional and international.[3]

**Strategy.** A roadmap for the implementation of a policy, which contains specific objectives, targets and instruments to address issues that might stimulate or impede the comparative advantage of the sector and obstruct its development.[3]

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[1] **Environmental Systems Research Institute (ESRI).** 2001. The ESRI press dictionary of GIS terminology. In: *ESRI* [online]. USA. [Cited 30 June 2013]. http://support.esri.com/index.cfm?fa=knowledgebase.gisDictionary.gateway

[2] **University of Nebraska-Lincoln.** 2005. Virtual Nebraska glossary. Remote sensing glossary. In: *University of Nebraska-Lincoln* [online]. USA. [Cited 30 June 2013]. http://casde.unl.edu/glossary/r.php

Fisheries and aquaculture:

[3] **Brugère, C., Ridler, N., Haylor, G., Macfadyen, G. & Hishamunda, N.** 2010. *Aquaculture planning: policy formulation and implementation for sustainable development*. FAO Fisheries and Aquaculture Technical Paper No. 542. Rome, FAO. 70 pp. (also available at www.fao.org/docrep/012/i1601e/i1601e00.pdf).

[4] **Crespi, V. & Coche, A., comps.** 2008. *Glossary of aquaculture/Glossaire d'aquaculture/Glosario de acuicultura*. Rome, FAO. 401 pp. (Multilingual version including Arabic and Chinese). Includes a CD–ROM/Contient un CD–ROM/Contiene un CD–ROM. (also available at www.fao.org/fi/glossary/aquaculture).

[5] **Ehler, C. & Douvere, F.** 2007. *Visions for a sea change*. Report of the First International Workshop on Marine Spatial Planning. Intergovernmental Oceanographic Commission and Man and the Biosphere Programme. IOC Manual and Guides No. 48, IOCAM Dossier No. 4. Paris, UNESCO. Further details on UNESCO's marine spatial planning are available at www.unesco-ioc-marinesp.be.

[6] **FAO.** 1995. *Code of Conduct for Responsible Fisheries*. Rome. 41 pp. (also available at www.fao.org/DOCREP/005/v9878e/v9878e00.htm).

[7] **FAO.** 2003. *Fisheries management. 2. The ecosystem approach to fisheries*. FAO Technical Guidelines for Responsible Fisheries No. 4, Suppl. 2. Rome. 112 pp. (also available at www.fao.org/docrep/005/y4470e/y4470e00.htm).

[8] **Soto, D., Aguilar-Manjarrez, J. & Hishamunda, N., eds.** 2008. *Building an ecosystem approach to aquaculture. FAO/Universitat de les Illes Balears Expert Workshop, Palma de Mallorca, Spain, 7–11 May 2007*. FAO Fisheries and Aquaculture Proceedings No. 14. Rome, FAO. 221 pp. (also available at www.fao.org/docrep/011/i0339e/i0339e00.HTM).

Additional sources:

See Glossary (pp. 163–166) in: Aguilar-Manjarrez, J., Kapetsky, J.M. & Soto, D. 2010. *The potential of spatial planning tools to support the ecosystem approach to aquaculture. FAO/Rome Expert Workshop, 19–21 November 2008, Rome, Italy*. FAO Fisheries and Aquaculture Proceedings No. 17. Rome, FAO. 176 pp. (also available at www.fao.org/docrep/012/i1359e/i1359e00.htm).

See Glossary (pp. 87–97) in: Carocci, F., Bianchi, G., Eastwood, P. & Meaden, G.J. 2009. *Geographic information systems to support the ecosystem approach to fisheries*. FAO Fisheries and Aquaculture Technical Paper No. 532. Rome, FAO. 120 pp. (also available at www.fao.org/docrep/012/i1213e/i1213e00.htm).

## BACKGROUND

1. A Regional Technical Workshop on Spatial Planning for Marine Capture Fisheries and Aquaculture was conducted in response to recommendations made during the fourth meeting of the Working Group on Aquaculture (WGA) of the Regional Commission for Fisheries (RECOFI), held in Muscat, Oman (27–28 January 2009), and the fifth session of RECOFI, held in Dubai, the United Arab Emirates (12–14 May 2009). The workshop, which took place in Doha, Qatar (24–28 October 2010), was hosted by the Department of Fisheries Wealth, Ministry of Environment, the State of Qatar. Twenty-one delegates participated representing seven RECOFI member countries (Bahrain, Iran [Islamic Republic of], Kuwait, Oman, Qatar, Saudi Arabia and the United Arab Emirates) and FAO. The Regional Strategy described in the workshop report (FAO/Regional Commission for Fisheries, 2011)[1] constitutes a solid and sound basis upon which to develop a programme for the development of the capacity to use spatial tools in fisheries and aquaculture management and planning.

2. The last and Sixth Session of RECOFI, held in Rome in May 2011, agreed to adopt an FAO/RECOFI joint Working Group on Aquaculture (WGA) and Working Group on Fisheries Management (WGFM) regional spatial planning approach to marine capture fisheries and aquaculture for the RECOFI region, and, within available resources, to provide the necessary support for follow-up action for the implementation of the Regional Strategy completed in the State of Qatar in 2010.

3. The preparatory work for the development programme document was finalized before the technical workshop, between October and November 2012. It included: (i) finalization, implementation and analysis of the questionnaire survey (July–August 2012); (ii) implementation of a regional technical workshop in Cairo, the Arab Republic of Egypt (25–27 November 2012); and (iii) preparation and finalization of a proposal for a Spatial Planning Development Programme for Marine Capture Fisheries and Aquaculture in RECOFI member countries.

4. This report documents the outputs of the RECOFI Regional Technical Workshop on "A Spatial Planning Development Programme for Marine Capture Fisheries and Aquaculture" (hereafter termed the "Development Programme"), which was held from 25 to 27 November 2012 at the FAO Regional Office for the Near East and North Africa in Cairo, Egypt. The technical workshop prospectus is provided in Appendix 3.

## OPENING OF THE WORKSHOP

5. Dr Piero Mannini, Senior Regional Fishery Officer, FAO, Regional Office for the Near East and North Africa, welcomed the participants from the RECOFI member countries and resource experts on behalf of the Assistant Director-General, Regional Representative for the Near East and North Africa, and expressed their pleasure in hosting this technical workshop. In his introductory note, Dr Mannini reminded the workshop attendees that RECOFI was empowered to formulate and recommend measures for the conservation and management of living marine resources. Thus, spatial planning for marine capture fisheries and aquaculture, using ecosystem approaches to fisheries and aquaculture, fells well within the remit of the work of the Commission. He noted that the use of spatial planning tools for marine capture fisheries and aquaculture could greatly help in the identification, analysis and possible allocation of specific geographical areas to be used for marine capture fisheries and aquaculture, particularly in those countries that have limited natural resources, which are in high demand by competing users. He highlighted the fact that spatial tools could also simplify the process of farm site selection for aquaculture and could match other demands on the marine space.

[1] FAO/Regional Commission for Fisheries. 2011. *Report of the Regional Technical Workshop on Spatial Planning for Marine Capture Fisheries and Aquaculture*. *Doha, the State of Qatar, 24–28 October 2010.* FAO Fisheries and Aquaculture Report No. 961. Rome. 118 pp. (also available at www.fao.org/docrep/014/i2054e/i2054e00.pdf).

6. Dr José Aguilar-Manjarrez, Aquaculture Officer, Aquaculture Branch (FIRA), FAO Fisheries and Aquaculture Department, Rome, welcomed the participants and resource experts and gave a brief background to the workshop.

## PURPOSE OF THE WORKSHOP

7. The objectives of the workshop were to:

- undertake a technical seminar on current topics on spatial planning for marine capture fisheries and aquaculture, and receive feedback from workshop participants on recent and relevant spatial planning projects from each RECOFI member country;
- present the outcomes of the questionnaire survey on a development programme for marine capture fisheries and aquaculture;
- prepare and finalize a proposal and an initial action plan for a development programme for marine capture fisheries and aquaculture in RECOFI member countries based on the outcomes of the regional survey, workshop brainstorming and other deliberations.
- undertake a facilitated activity to identify potential pilot projects on marine fisheries and aquaculture.

8. The workshop agenda is presented in Appendix 1. The Secretariat explained the workshop objectives, the process to be adopted, guidelines for the working group discussions and the expected outputs in detail.

## WORKSHOP PARTICIPATION

9. A total of 12 delegates participated, representing six RECOFI member countries (Bahrain, Iraq, Oman, Qatar, Saudi Arabia and the United Arab Emirates) and FAO (staff from Rome, the Subregional Office for North Africa and consultants). The list of participants is included as Appendix 2.

## TECHNICAL SEMINAR

10. The Secretariat presented two technical presentations on current topics in spatial planning for marine capture fisheries and aquaculture. The presentations were flexible to allow for discussion, and were aimed at providing information to assist in developing the Development Programme. The presentations were:

- Identification of potential aquaculture zones in the Kingdom of Saudi Arabia using satellite image analysis and GIS and an estimate of sustainable carrying capacity (P. White).
- Data and spatial analytical skills available among the RECOFI countries that could be applied to fisheries and aquaculture (P. Longdill).

11. In the presentation “Identification of potential aquaculture zones in the Kingdom of Saudi Arabia using satellite image analysis and GIS and an estimate of sustainable carrying capacity”, the objectives were to identify aquaculture potential along the Red Sea and Gulf coasts with and without consideration of other potential uses of the coast and to identify aquaculture zones that will be designated for aquaculture development, which will be granted through a participatory process with relevant stakeholders. By analysing satellite images and other coastal data, maps of potential areas for onshore, nearshore and offshore aquaculture were developed, taking into consideration necessary buffers between aquaculture and sensitive habitats, areas where aquaculture is not allowed and areas of potential conflict for aquaculture. The carrying capacity of the identified potential areas was then estimated using a precautionary approach, thus allowing an estimate of the potential coastal aquaculture production for all of Saudi Arabia.

12. The presentation "Data and spatial analytical skills available within the RECOFI countries: applicability to fisheries and aquaculture" was based on the observations of Dr. Peter Longdill, who is experienced in the field of spatial data science and its application for fisheries, aquaculture and marine science, and has been living and working within the RECOFI region for the past six years. The presentation highlighted that there were several major opportunities, and also some barriers, with respect to the availability of spatial data for fisheries, aquaculture or marine spatial planning (MSP) studies. Broadly, the presentation noted that there were high-quality and relevant data sets in existence (e.g. light detection and ranging [LiDAR], aerial imagery), often collected in association with urban development. Barriers limiting the full application (i.e. sharing) of such data sets were suggested to be primarily institutional. It was further suggested that in order to overcome these barriers, high-level cooperation would be required between relevant government departments (i.e. those with the data sets and those wishing to conduct a project using them). Environmental spatial data sets (e.g. water quality) could be expected to be less available, and could require dedicated collection or, alternatively, validation for pre-existing data sets. The presentation concluded by noting that for the successful application of spatial data to fisheries and aquaculture, three requirements should be met: (i) relevant data (environmental, institutional, constraints, etc.); (ii) spatial analytical technical skills; and (iii) fisheries and aquaculture technical knowledge.

**SUMMARY OF THE PROPOSED REGIONAL STRATEGY FOR SPATIAL PLANNING**

13. The introductory part of the strategy sets out its evolution beginning with a recommendation of the RECOFI for a joint workshop between the WGA and the Working Group on Fisheries Management (WGFM) on the use of spatial planning tools. As a background to the strategy, the status of both aquaculture and capture fisheries in the RECOFI area waters is described, thus providing part of the rationale for spatial planning. Also outlined is the main purpose, which is to present a strategy to enhance and accelerate spatial planning for mariculture and marine capture fisheries in the region. The vision of the strategy is "To illustrate how spatial planning tools are one essential element to achieving sustainable clean, healthy, safe, productive and biologically diverse marine seas in the RECOFI region, and how they allow for mariculture and marine fishery production activities to be maximized while at the same time taking into account the other users of the marine space." The guiding principles that underlie the outlined components of the strategy are founded broadly on the ecosystem approach to aquaculture (EAA) and the ecosystem approach to fisheries (EAF), allied to the need to ensure that all legitimate uses of the marine space can continue on the basis of sustainability. The strategy is more specifically guided by the principles of MSP.

14. In a further presentation on MSP, the participants were introduced to its main concepts and steps. An explanation was first provided as to why RECOFI's "Regional Strategy" for spatial planning should be embedded within the overall context of MSP. Thus, it was explained that the marine space was becoming crowded in terms of marine resource exploiters, and that if these exploiters were all to be successful in the future, then activities would have to be rationalized with respect to their use of this space. In addition, it was explained that MSP is a framework that is gaining considerable importance around the world. It consists of a public process for analysing and allocating the spatial and temporal distribution of human activities in marine areas to achieve ecological, economic and social objectives that have usually been specified through a political process. Marine spatial planning is ecosystem-based, area-based, integrated, adaptive, strategic and participatory. Various countries have started to use marine spatial management to achieve sustainable use and biodiversity conservation in ocean and coastal areas.[2] If all marine activities are to continue in a successful and sustainable way in a crowded, enclosed and stressed marine area such as the Gulf, it is essential that MSP be applied.

[2] UNESCO-Intergovernmental Oceanographic Commission. 2012. Marine spatial planning. In: *Marine spatial planning initiative* [online]. France. [Cited 30 June 2013]. www.unesco-ioc-marinesp.be/marine_spatial_planning_ msp

## COUNTRY PRESENTATIONS

15. In preparation for the technical workshop, each country[3] was requested to prepare a 15-minute presentation of a recent and relevant spatial planning project from its country. The presentations made during the workshop summarized the following aspects of their projects: (i) description of developed, ongoing or planned project (or projects); (ii) time frames and objectives; (iii) data collection, equipment, methods and analysis; (iv) results, outputs and conclusions; (v) budget; (vi) main issues, benefits and challenges; and (vii) a list of ongoing initiatives relevant to the objectives of the workshop. Original PowerPoint presentations as completed by participants are available at the Regional Aquaculture Information System (RAIS) website (www.raisaquaculture.net), and the summary of each country's presentation along with the names of the presenters are provided below:

- Bahrain (Abdulkarim Al-Radhi and Ahmed Abdulwahab Al-Radhi);
- Iraq (Tareq Hasan Al-Rubaye and Arwa Ali Majeed);
- Oman (Yahya Saif Hamdan Al-Wahaibi);
- Qatar (Shekha Darwish Saeed and Abdul Rahman Siddiq Al Bin Ali);
- Saudi Arabia (Mahmood Abdulaziz Al Noori and Khalid Saleh Alshaye).

16. Bahrain provided a presentation that summarized the contribution of fisheries to the country and its economy, followed by a description of the demands that fisheries make (or have made) on local marine environments and habitats. A background to its MarGIS I and II projects was provided, which is an online marine environmental geographic information system (GIS) that aims to help public- and private-sector organizations to understand the location and nature of marine habitats. The presentation noted that there is currently an initiative in Bahrain to prepare a GIS application to amalgamate key environmental information along with natural and marine resource information in order to support and inform the management of fisheries. This application is intended to be a web-based system, allowing users to access spatial and attribute information on fisheries-relevant data sets (e.g. environmental habitats, traditional fishery areas including method of fishing, industry and infrastructure). The application is intended to allow technical users to view, query and retrieve information on various data sets (layers), which in turn provides them with a tool to enhance decision-making processes.

17. The presentation from Iraq indicated that there were no present or ongoing spatial planning projects for marine fisheries in the country. It was noted that such spatial tools were being used in the agriculture and inland fisheries sectors within the country, and that there was awareness, interest and enthusiasm for applications to be made in the marine fisheries and aquaculture sectors. It was recognized that, because of the limited extent and the location of Iraq's territorial waters, and the close proximity of both Kuwait and Iran (Islamic Republic of), the use of spatial tools in some form of cross-border cooperation would be a suitable way to address the management of fisheries and aquaculture.

18. Oman presented two case study projects. The first study addressed "the potential use of GIS applications for fisheries management", while the second addressed a "vessel monitoring system" implemented for commercial fishing vessels. The first study aimed to design and develop a spatial environmental database for the Quriyat region to support fisheries management and decision-making. The project included the collection and collation of spatial data (environmental, socio-economic, fish-landing areas and statistics over time) and also non-spatial data (employment details, licensing and registration). This initial study required two persons for three months to complete, and resulted in the provision of useful spatial fisheries data for managers. Oman also presented its vessel monitoring system (VMS) for commercial fishing vessels, which was initially implemented in 2001. The system aims to identify the location of vessels (including distance to other vessels and depth of water),

[3] The United Arab Emirates did not prepare a presentation.

enforce authorized and non-authorized fishing areas, and communicate this information in near real time (updated every half hour) to fisheries managers.

19. Qatar presented a project aiming to "implement an ecosystem approach to fisheries and marine resources". The project, managed by the Department of Fisheries and focusing on the sustainable management of fishery resources, started in July 2011 and is anticipated to run for five years. The main components of the project are developing a web-based fisheries information system, providing a foundation for MSP, and developing models of maximum sustainable/economic yields for fisheries. This substantial project included detailed data collection via both surveys and interviews of fishers, and also spatially based electronic methods (e.g. VMSs, acoustic underwater surveys). It was also noted that the natural environment surrounding Qatar is under stress from both natural and anthropogenic activities. Accordingly, it was concluded that the sustainable management of fisheries resources was an important aspect not only for the environment but also for national food security.

20. Saudi Arabia presented a summary of currently available and relevant spatial data within the country, including fish farm locations, digital topographic maps, Landsat images, Spot images, RapidEye images, soils, geology and flora. It was noted that there was strong spatial analytical knowledge and tools within the information technology section of the Ministry of Agriculture. Currently, spatial tools are being utilized in an agricultural sense for early warning of diseases, and in an aquaculture sense in relation to a vehicle locator system (monitoring of land-based vehicle movements between farms). Saudi Arabia is currently implementing mobile spatial data capture and remote upload to its centralized spatial database.

**REVIEW OF THE QUESTIONNAIRE SURVEY ANALYSIS**

21. In the presentation "Outcomes of the survey on the Development Programme for marine capture fisheries and aquaculture", a synopsis of the questionnaire survey was given. The aims of the survey were to: (i) determine the status of implementation of the Regional Strategy for spatial planning; and (ii) obtain information on national capacities and on the agencies mandated to implement fisheries and aquaculture management of spatially based projects in each of the eight RECOFI member countries. The results on the status of implementation of the Regional Strategy outlined in 2010 (see FAO/Regional Commission for Fisheries, 2011) indicated that about 60 percent of all the elements (making up the strategy) for all RECOFI countries are only at an initial "discussion" stage, 22 percent of elements have been "initiated" to some extent, and 18 percent of the elements have been implemented. Only Qatar has made significant advances.

22. The results of the questionnaire survey revealed that 12 fisheries and aquaculture spatially based projects had been, or were being, undertaken. The majority of projects were in the fisheries management sector or in vessel control and environmental data analysis. The aquaculture projects were primarily aimed at identifying suitable sites for aquaculture development, but also for developing a database of existing farm locations.

23. Most countries reported having a programme of continuing spatial data and information collection and storage. All RECOFI member countries, except Saudi Arabia, noted a need for additional capacity building in the practical use of GIS. Only one country (Qatar) is able to offer capacity building both in the awareness of the importance of spatial planning and in practical GIS training, although Oman could contribute to the latter. Only in the case of Qatar were there stronger indications that GIS for marine purposes had undergone some considerable planning, and that these plans had a strong potential to be implemented.

## REVIEW OF THE PROPOSED CONTENT OF THE SPATIAL PLANNING DEVELOPMENT PROGRAMME

24. The Regional Strategy completed in Qatar in 2010 and endorsed by the Commission in May 2011 sets out 4 programme components, 12 elements and 30 activities. The purpose of this current Development Programme is to address some of the key elements of the Regional Strategy in order to develop a programme to allow for spatially based planning and, thus, enhanced management of marine capture fishery activities and aquaculture in the RECOFI region.

25. The key elements of the proposed Development Programme are based on: (i) the Regional Programme for Implementing a Strategy on Spatial Planning for Marine Capture Fisheries and Aquaculture in RECOFI member countries; (ii) inputs received through a questionnaire survey conducted during 2012; and (iii) feedback received from participants attending the workshop in Cairo, Egypt. The Development Programme is essentially based on 4 of the components, 8 of the 12 elements, and 14 of the 30 activities from the 2010 Regional Strategy.

26. In order to convey the Development Programme in a meaningful way for workshop participants, the components, elements and activities from the 2010 Regional Strategy were grouped into seven topic areas, each to represent a cohesive and simplified version of the Development Programme, as follows:[4]

27. **Overseeing fisheries and aquaculture GIS work.** For fisheries to be successfully managed in an area such as the Gulf, where numerous other activities also take place in a shared marine space, it will be essential to introduce MSP. Marine spatial planning will cover the integration of these marine activities, with additional ecosystem approaches being adopted to best promote both fisheries and aquaculture management. These facts mean that all of the spatially based work will have to be carefully planned and managed, i.e. in a working environment that requires multiple stakeholder involvement, extensive cooperative working, the establishment of joint legal structures and major inputs of higher-level decision-making. Both MSP and EAA/EAF considerations will need to be operative at national and regional levels, with "general spatial planning committees" at both levels, as well as establishing "fisheries and aquaculture spatial committees", and perhaps committees for: (i) marine recreation; (ii) energy; (iii) coastal development; (iv) mineral and marine resources; and (v) shipping. At both regional and national levels, it will be important to appoint a "fisheries/aquaculture GIS champion", i.e. a person who at each level can take overall responsibility for ensuring that the GIS work is progressing satisfactorily and in unison across the RECOFI countries. See also concept note on "Marine spatial planning in marine waters for the State of Qatar and three neighbouring countries" in Annex 1 of Appendix 9.

28. **Capacity building for higher-level decision-makers.** For any programme of work to be successful, it is important that decision-makers at various levels are familiar with what the work will be concerned with, and that they firmly support its aims. This almost certainly means that some level of capacity building will be required. It is important to establish who the decision-makers are, in what sectors they may be employed, and what are the preferred ways of imparting the required information to people who are usually extremely busy. Briefing meetings and/or succinct literature (leaflets, summaries or brochures) are possibly optimum ways of conveying the required information. For those decision-makers having more direct involvement with spatial activities, then it is likely that more extensive familiarization may be required, possibly in a workshop environment.

[4] Appendix 4 links these topic areas with the original activities, as shown in Table 1 of FAO/Regional Commission for Fisheries, 2011 (see note 1).

29. **Prioritizing GIS work and identifying pilot projects**. Results from both the questionnaire analyses and from workshop presentations and discussions reveal that there is a wide range of spatial analyses that are desirable in both the fisheries and aquaculture fields. For some countries, there is uncertainty over the potential of GIS-based procedures to be of assistance. This is due to a lack of familiarity with both the technology (its capability and potential) and data requirements. One way of overcoming these problems is for countries to participate in pilot projects. After further discussion and advice, most countries have selected suitable fisheries and aquaculture-based projects to pursue, i.e. based on important perceived local issues. With regard to marine fishery projects, these are generally more difficult to undertake because data requirements often include those that require knowledge of marine spatial distributions of, for example, life stages of species or of specific marine habitats/ecosystems, and these data are not yet available. In some cases, it has therefore been necessary to suggest pilot projects that are within the individual country's current capabilities.

30. **Where and how will the GIS function best?** Spatial planning and analyses work will need to be carefully optimized in terms of: (i) its physical locations within the RECOFI area; (ii) the scale it should operate at; (iii) the physical architecture of the information technology (IT) systems; (iv) the software used; (v) the personnel and management structure; and (vi) a host of other operating considerations. For some countries, GIS operations might best be seen as being in the IT domain, whereas other countries will prefer that the system is directly under the direction of fisheries or aquaculture personnel. It is important that these considerations are carefully made, especially given that all spatially based work should be carried out in conjunction with other private and public enterprises, with other users of the marine space and through cooperative working with other RECOFI member countries. Annex 2 of Appendix 9 shows the progression of stages through a GIS project and the human influences affecting these process stages.

31. **Practical training in GIS.** It is clear from questionnaire feedback that the situation with respect to a RECOFI country's ability to physically address the required GIS work is highly variable. While there are frequently small centres of GIS excellence in individual countries, these are usually only found in administrative locations and centres. It is rare to find adequate expertise in fishery/aquaculture centres. It is, therefore, clear that training needs will be variable, as will be the potential to supply these needs. Matching training needs to the demand will, in some cases, be a primary task even before elementary GIS processing can begin. The GIS training will need to be addressed on a RECOFI-wide basis, probably with the help of local IT consultants. See also concept note on "Provision of GIS training for RECOFI member countries personnel as required" in Annex 1 of Appendix 9.

32. **Identifying and acquiring data for GIS.** As with the other aspects concerning the adoption of spatial planning methods and working practices, the data situation is highly variable between and within countries. For marine fisheries and mariculture (i.e. off-the-coast and offshore), many of the data requirements refer to dynamic variables. This often means that much time and expenditure will be required to identify and collect the essential data upon which spatial analyses can be based.

33. **Updating and managing GIS data and information.** Once the data are gathered, they will need to be regularly edited, updated and managed in various ways, e.g. through the use of database management systems. Indeed, not only will this apply to data, but also to the array of hardware, software, training and other prerequisites that make spatial analysis possible. It will be especially important that all staff are kept adequately trained and updated and that they are familiar not only with developments in GIS, remote sensing, etc., but also with developments in aquaculture or fisheries and peripheral technologies (e.g. models, databases).

## WORKING GROUP DISCUSSIONS

34. The workshop participants were divided into two working groups, with working group 1 comprising mainly individuals with technical expertise on marine capture fisheries, while working group 2 consisted mainly of individuals with expertise in aquaculture.

35. The Secretariat presented the working group discussion guidelines. It was reiterated that, because the main focus of the technical workshop was to complete a Development Programme, working groups were to "review" the outline of the Development Programme and to "brainstorm" ideas for potential pilot projects that could use spatial tools using the EAF and aquaculture process/steps. In order to guide workshop attendees, a general presentation was made on the main concepts and principles of the EAA and the EAF and their relevance to the sustainable development of fisheries and aquaculture in RECOFI member countries.

36. The working groups were tasked with:

- examining the overall Development Programme components, essential elements and activities both from regional and national perspectives and from the overall goal;
- identifying specific titles, objectives, geographic areas and responsibilities for each of the pilot projects.

### Prioritizing key issues and corresponding pilot projects

37. In order to familiarize the workshop attendees with the ecosystem approach, a presentation was made on the principles of sustainable development, where sustainable is not restricted to ecological considerations but includes economic and social considerations and their interaction with ecological ones. The participants were then instructed to consider the three main objectives of the ecosystem approach for identifying projects:

- Ecological well-being – all the relevant ecological "assets" (e.g. stocks, habitats, ecosystems) and the issues/impacts being generated from any source that may be affecting them.
- Human well-being – the social and/or economic "outcomes" currently being generated. These could be both good, i.e. those outcomes the community wants to have generated (e.g. food security, economic development), and bad, i.e. those it wants to avoid (e.g. conflicts, pollution, overfishing).
- Facilitating the achievement of both – the management and institutional "systems" are in place or proposed to deliver the desired outcomes (e.g. access and tenure systems, compliance, democratic processes, conflict resolution), along with the external "drivers" (not controlled by management), which may be affecting performance (e.g. pressure from other activities).

38. As a first step in the EAF/EAA process, it was essential to define the scope and scale of the fishing and aquaculture activities, communities, and the political and geographic areas that will or will not be covered by the project area. The scope and definition of the ecosystem boundaries were identified as fisheries and aquaculture areas within individual countries Exclusive Economic Zones, with the possibility of regional projects if common issues were identified. Based on the agreed scope of the aquaculture or fisheries system and the community values to be achieved, the next step was to identify and examine all issues relevant to aquaculture and fisheries to determine what potential pilot project could be proposed to generate the best community and sustainability outcomes. Annex 3 in Appendix 9 shows the EEZs of RECOFI member countries.

39. The main issues identified for "marine fisheries" were environmental factors, such as water temperatures, red tides and high salinity, and anthropogenic factors, such as overfishing (including illegal fishing), climate change, pollution and dredging causing habitat destruction. The main issues identified for "mariculture" were the identification of suitable sites for aquaculture, identification of suitable species for production, the identification of suitable culture systems, and the development of hatcheries.

40. Based on the issues identified, potential fisheries and aquaculture concept notes for pilot projects were then briefly developed for each participating country (Appendix 5). After the workshop, but still in consultation with workshop participants, the international consultants further developed the pilot projects, mainly using the following project structure: title of the project; objectives; geographical area; data requirements; data sources; methods; tools and indicators; use of GIS, remote sensing and MSP; outputs and outcomes; budget; proposed agency undertaking the project; time frame for implementation; and proposed funding source.

**Review of the proposed content of the Spatial Planning Development Programme**

41. The working groups were invited to review and discuss the components of the draft Development Programme, indicating for each activity the suggested time frame (short, medium or long term), the priority (high, medium or low) and the in-country agency with primary responsibility. The results were then presented in the plenary session. A discussion followed in which the pilot projects from each country were revised. The results of the working group discussions are summarized in Appendix 4.

**Approval of the outline of the Spatial Planning Development Programme**

42. During the final day of the workshop, the Secretariat presented the revised outline for the Development Programme, which is essentially based on 4 of the components, 8 of the 12 elements and 14 of the 30 activities from the 2010 Regional Strategy. Discussion then followed and the outline was unanimously accepted by the workshop participants. The Secretariat was charged with developing a final draft version for approval by workshop participants and the WGA and WGFM focal points.

**THE WAY FORWARD**

43. During the final workshop session, the Secretariat presented the final list of pilot projects (Appendix 5) and the interim work, i.e. proposed future activities that will need to be accomplished to complete the proposal for the Development Programme, and the agencies responsible for completing each task and a proposed time frame (Appendix 6). A budget for the Development Programme was estimated after the workshop, and this appears in Appendix 7. The major outputs arising from the workshop are included in this report as appendixes, as indicated below:[5]

1. RECOFI Spatial Planning Development Programme for Marine Capture Fisheries and Aquaculture. Questionnaire Survey Analysis Report (Appendix 8);[6]
2. Proposal for a Spatial Planning Development Programme for Implementing a Strategy on Spatial Planning for Marine Capture Fisheries and Aquaculture in RECOFI member countries, (Appendix 9).[7]
3. Concept notes for pilot projects on marine fisheries and aquaculture (Annex 1 in Appendix 9).

[5] Final drafts of these documents prepared by the Secretariat were distributed in May 2013 to workshop participants and RECOFI WGA and WGFM focal points for comments and approval.

[6] To be cited as: Aguilar-Manjarrez, J., Meaden, G.J., White, P. & Longdill, P. 2013. RECOFI Spatial Planning Development Programme for Marine Capture Fisheries and Aquaculture. Questionnaire Survey Analysis Report. *In* FAO/Regional Commission for Fisheries. *Report of the Regional Technical Workshop on Spatial Planning Development Programme for Marine Capture Fisheries and Aquaculture. Cairo, the Arab Republic of Egypt, 25–27 November 2012.* FAO Fisheries and Aquaculture Report No. 1039. Rome. pp. 26–47.

[7] To be cited as: RECOFI. 2013. Proposal for a Spatial Planning Development Programme for Implementing a Strategy on Spatial Planning for Marine Capture Fisheries and Aquaculture in RECOFI Member Countries. *In* FAO/Regional Commission for Fisheries. *Report of the Regional Technical Workshop on Spatial Planning Development Programme for Marine Capture Fisheries and Aquaculture. Cairo, the Arab Republic of Egypt, 25–27 November 2012.* FAO Fisheries and Aquaculture Report No. 1039. Rome. pp. 56–124.

## CLOSING REMARKS

44. A Development Programme has been formulated so as to best put into place the required measures to address the management needs of the RECOFI marine area in the coming decades, with these management needs arising out of a set of problems that have their basis in a whole series of spatially based issues. This Development Programme, therefore, follows a series of logical and attainable measures that best helps redress the situation, with the longer-term goal of the various users of the marine space working in harmony for the benefit of all, and for the natural ecosystems to be functionally in balance and moving towards a situation where maximum marine productivity is attained and maintained.

45. The primary strength of the proposed Regional Strategy and Development Programme is that they will allow for the delivery of spatial planning tools to enable a wide spectrum of analyses to address spatial problems for fishery and aquaculture planning and management. Spatial planning tools will not solve every marine management problem but they will provide the spatial framework within which RECOFI member countries will have more options to solve problems through sound decision-making.

46. A key regional activity and a core component of the Regional Strategy will be to identify RECOFI countries and appropriate agencies (i.e. private and public departments, or institutions that use the marine space) that are willing to cooperate in developing regional plans (MSPs) to improve the environmental, social and economic conditions of the RECOFI region and to agree on cooperative working environments, including the need to share data.[8] It will be up to RECOFI members to address issues concerned with governance-related recommendations contained in the Regional Strategy at government level, including, most importantly, acceptance by RECOFI countries on current approaches to MSP, fishery zoning and the adoption of the EAA and EAF.

47. It will be up to RECOFI to fund the Development Programme components, and, likewise, it will be the responsibility of each member country to implement its pilot projects and/or to seek synergies for collaborative work with neighbouring countries and/or countries with similar needs and priorities.

[8] It is important to stress that it is essential to achieve working cooperation between all eight RECOFI members if a satisfactory resolution of marine-based problems in the Gulf is to be forthcoming. For example, if a major RECOFI country were unwilling to cooperate in the proposed Regional Strategy, then the chances of achieving "fisheries/aquaculture success" for any of the other countries would be very much compromised.

**APPENDIX 1**

## Workshop agenda

| Day | Activities | Presenter |
|---|---|---|
| **Saturday, 24 November** | Arrival of participants in Cairo, Egypt | |
| **Day 1 Sunday, 25 November** | | |
| 09.00–12.00 | Opening ceremony | Aguilar |
| | Background and objectives of the workshop | Aguilar |
| | Self-introduction of workshop participants | Carocci |
| | Technical seminars | |
| | Identification of potential aquaculture zones in the Kingdom of Saudi Arabia using satellite image analysis and GIS and an estimate of sustainable carrying capacity | White |
| | Data and spatial analytical skills (government and commercial sector) available among the RECOFI countries that could be applied to fisheries and aquaculture | Longdill |
| | Lunch | |
| 13:30–17:00 | Summary of Regional Strategy (i.e. FAO Fisheries and Aquaculture Report No. 961) | Meaden/Aguilar/Carocci |
| | *Presentation from each country on ongoing projects and/or ideas for projects. One presentation per country delivered by country expert. | Workshop Secretariat |
| **Day 2 Monday, 26 November** | | |
| 09:00–12:00 | Outcomes of the survey on spatial planning development programme for marine capture fisheries for RECOFI | Longdill/Meaden/White |
| | Lunch | |
| 13:30–17:00 | Presentation on the outline of a spatial planning development programme | Meaden/White |
| | Working groups discussions – Two working groups to discuss and complete spatial planning development programme | Workshop Secretariat |
| **Day 3 Tuesday, 27 November** | | |
| 09.00–12.00 | Continue spatial planning development programme – Working group discussions | Workshop Secretariat |
| | Lunch | |
| 13:30–17:00 | Working group presentations | Workshop Secretariat |
| | Discussions at plenary | Workshop Secretariat |
| | Conclusions, adoption of spatial planning development programme and way forward<br>Closing ceremony | Workshop Secretariat<br>Mannini/Aguilar |
| **Day 4 Wednesday, 28 November** | | |
| **Friday, 29 November** | Departure of participants | |

* FAO Secretariat provided a template to use as a guide to prepare presentations.

**APPENDIX 2**

**List of participants**

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**APPENDIX 3**

## Workshop prospectus

### Background

A Regional Technical Workshop on Spatial Planning for Marine Capture Fisheries and Aquaculture was conducted in response to recommendations made during the fourth meeting of the Working Group on Aquaculture (WGA) of the Regional Commission for Fisheries (RECOFI) held in Muscat, the Sultanate of Oman (27–28 January 2009) and the fifth session of RECOFI held in Dubai, the United Arab Emirates (12–14 May 2009). The workshop, which took place in Doha, the State of Qatar (24–28 October 2010), was hosted by the Department of Fisheries Wealth, Ministry of Environment, the State of Qatar. Twenty-one delegates participated representing seven RECOFI member countries (the Kingdom of Bahrain, the Islamic Republic of Iran, the State of Kuwait, the Sultanate of Oman, the State of Qatar, the Kingdom of Saudi Arabia, and the United Arab Emirates) and FAO. The workshop report (FAO/Regional Commission for Fisheries, 2011)[1] constitutes a solid and sound basis upon which to develop a Development Programme for the development of the capacity to use spatial tools in fisheries and aquaculture management and planning.

**Purpose:** The purpose of this workshop is to complete a Development Programme outline in as much detail as possible, including preliminary budget estimates for the development of the capacity to use spatial tools in fisheries and aquaculture management and planning.

**Approach:** The approach for this workshop will combine training in the form of lectures and discussions with the focus on the completion and endorsement of a Development Programme.

**Participation:** Eight RECOFI member countries (the Kingdom of Bahrain, the Islamic Republic of Iran, the Republic of Iraq, the State of Kuwait, the Sultanate of Oman, the State of Qatar, the Kingdom of Saudi Arabia and the United Arab Emirates) will be invited to participate in the workshop.

**Process:** Plenary presentations and working group discussions.

**Products:**

- Draft proposal of a development programme outline including preliminary budget estimates that will either (1) require extra budgetary funding, thus for consideration at the next RECOFI session in May 2013 and/or (2) may be funded independently by single RECOFI member countries.
- Regional workshop report.

**Date and location:** The workshop will be held at the FAO Regional Office for the Near East, Egypt, Cairo, from 25–27 November 2012.

Further information (hotel venue, participant list, and other logistic arrangements) about the workshop will be circulated as soon as available and any specific inquiries may be obtained by writing to:

[1] FAO/Regional Commission for Fisheries. 2011. *Report of the Regional Technical Workshop on Spatial Planning for Marine Capture Fisheries and Aquaculture. Doha, the State of Qatar, 24–28 October 2010*. FAO Fisheries and Aquaculture Report No. 961. Rome. 118 pp. (also available at www.fao.org/docrep/014/i2054e/i2054e00.pdf).

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**José Aguilar-Manjarrez** – PhD (1992–1996) and MSc (1991–1992) in Aquaculture Planning and GIS from the University of Stirling, the United Kingdom of Great Britain and Northern Ireland. Graduated in Oceanography in 1989 from the Faculty of Marine Sciences in Ensenada, Baja California Mexico. Sixteen years with the FAO/UN Fisheries and Aquaculture Department, first as a visiting scientist (1996–1998) then as a consultant (1998–2000), and since 2001 as an Aquaculture Officer in the Aquaculture Branch (FIRA). His responsibilities at FAO-FIRA cover two different areas: (i) GIS-related activities; and (ii) assistance to field projects on rural aquaculture in a number of countries in Latin America, Africa and Asia. Activities specific to GIS have broadly included: (i) the development of methodologies, technical papers, reviews and training materials on GIS applications to aquaculture, such as FAO Fisheries and Aquaculture Technical Paper No. 549 (www.fao.org/docrep/017/i3100e/i3100e00.htm); (ii) the construction of georeferenced information systems such as GISFish (www.fao.org/fishery/gisfish); and (iii) the formulation, implementation and review of field projects that have a GIS and/or remote sensing component. Main current interests are in aquaculture zoning and site selection.

**Fabio Carocci –** FAO Fisheries Information Assistant, Marine and Inland Fisheries Branch (FIRF). A graduate in Geological Sciences from the University of Rome, he has been engaged in computer science as applied to geography and cartography. His career has led him to specialize increasingly in the development of GIS data and applications to support the analysis of the status of marine fish resources and the formulation of fisheries management plans at international level. He has also provided technical support to a number of field projects with GIS components at national and regional levels in different areas of the world. He has gained experience with training in GIS, with a particular emphasis on marine fisheries management, targeting different levels of expertise, from courses for postgraduates to seminars for fisheries managers. He is currently focusing on the development of principles and guidelines for the application of GIS in an ecosystem approach to fisheries.

### FAO NATIONAL CONSULTANT

**Peter Longdill –** Following the completion of a BSc and a Postgraduate Diploma of Science at the University of Auckland (New Zealand) in 1999, he began working commercially with GIS in both New Zealand and Australia. Following this, in 2004, his focus turned to aquaculture, and he prepared his PhD thesis titled “Environmentally Sustainable Aquaculture: An Eco-Physical Perspective”. As a part of this study, among others, he prepared a paper titled “GIS-Based Models for Sustainable Open-Coast Shellfish Aquaculture Management Area Site Selection” in which he successfully combined “traditional” GIS planning for aquaculture with detailed numerical model outputs and remotely sensed data. Since 2006, he has been based in Doha, Qatar, where he manages a team providing environmental consultancy services to a range of clients, specializing in coastal and marine projects. The application of GIS to support coastal and marine problem solving and planning has been a key focus of his work. He has continued his active involvement in aquaculture, providing expert advice to regional authorities and management bodies in New Zealand related to site selection, planning, hydrodynamics, and ecological modelling as well as participating in FAO regional aquaculture and fisheries workshops.

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**Geoffery J. Meaden –** In 2008, he retired from his post as Principal Lecturer in Geography at Canterbury Christ Church University, the United Kingdom of Great Britain and Northern Ireland. He completed a first degree and Masters degree at London University. His PhD was titled “Optimum locations for fresh water fish farms in England and Wales”. He has carried out a number of GIS-based

assignments for FAO. At Canterbury Christ Church University, he directed a “Fisheries GIS Unit” for 12 years. This unit has undertaken a large number of research projects based on implementing and using GIS to enhance fisheries management. He was the lead author of two key publications at FAO that are still relevant and in great demand: Meaden and Kapetsky, 1991 (www.fao.org/DOCREP/003/T0446E/T0446E00.HTM) and Meaden and Do Chi, 1996 (www.fao.org/DOCREP/003/W0615E/W0615E00.HTM). He has recently led the updating of these manuals into a new FAO Fisheries and Aquaculture Technical Paper by Meaden and Aguilar-Manjarrez, 2013 (www.fao.org/docrep/017/i3102e/i3102e00.htm).

**Patrick G. White –** He is a specialist in temperate and tropical marine fish/shrimp production, the impact of aquaculture on the environment, site selection suitability and climate change impacts on aquaculture. He has more than 30 years’ experience in the aquaculture sector and has worked in the Mediterranean region for more than 20 years and the Near East for more than five years. He has worked in Saudi Arabia, Oman and Kuwait and has a good understanding of the local species and environment. He has worked on site identification projects using modelling and GIS, including:

- a study to identify potential freshwater, brackish-water and marine aquaculture sites, aquaculture zones and sustainable carrying capacity in Saudi Arabia;
- a study to identify potential marine cage sites in the Province of Krabi, Thailand;
- a study to develop the methodology for identifying potential sites and sustainable carrying capacity for mariculture parks in the Philippines.

**Outcomes of the workshop deliberations on the time frame, priority and agency with primary responsibilities for the different elements of the spatial planning development programme components**

| Topics | Activities (with Activity number in brackets) | Output(s) | Time frame (S, M, L) | Priority (H, M, L) | Responsibility |
|---|---|---|---|---|---|
| 1. Overseeing fisheries and aquaculture GIS work | Establish a "national marine GIS committee" (9)<br>Identify regional and national "fisheries/aquaculture GIS champions" (18) | Team of experts<br>Individual appointments | S<br>S | H<br>H | National<br>Regional/National |
| 2. Capacity building for higher-level decision-makers | Decision-makers at the highest level (15) | A promotional leaflet (or a set of leaflets) | S | H | RECOFI National/WGA/WGFM |
| | Middle-level decision-makers (16) | One-week regional workshop | S | H | RECOFI National/WGA/WGFM |
| 3. Prioritizing GIS work and identifying pilot projects | Prioritizing the GIS work (19) | Report | S | H | RECOFI/National |
| | Identifying pilot projects (19) | Report | S | H | RECOFI/National |
| 4. Where, and how, will the GIS function best? | Decide on locations for GIS work, plus work remit (25) | Report | S | H | RECOFI/National |
| | Develop the GIS structure needs (personnel, hardware, software, etc.) (26) | Report | S/M | H | RECOFI/National |
| | Procurement and implementation of GIS (27) | Acquisition of GIS system | S/M | H | RECOFI/National |
| 5. Practical training in GIS | Identify the availability of personnel having previous GIS training (17) | Report | S | M | National |
| | | | | | |
| | Assess what further regional or national GIS training is needed (17) | Report | S/M | M | RECOFI National/WGA/WGFM |
| | Identify training providers and then provide training(17) | GIS training workshops as required | S/M | M | RECOFI/National |
| 6. Identifying and acquiring data for GIS | Identify data needed for GIS projects (20) | Report | M | M | RECOFI National/WGA/WGFM |
| | Identify data sources (20) | Report | M | M | RECOFI/National |
| | Acquisition of new data (20) | Data acquired | M | M | RECOFI/National |
| | | | | | |
| 7. Updating and managing GIS data and information | Undertake data updating and editing (21) | Updated usable GIS data | M/L | H | RECOFI/National |
| | Establish secure data storage and management using database management systems (22) | Database management systems | M/L | H | RECOFI/National |
| | Establish library of hard-copy materials (23) | Hard-copy library | M/L | M | National |
| | Establish digital archives for data and information materials (24) | Digital archives | M/L | M | National |

*Notes:* Complete list of activities are described in workshop report (FAO/Regional Commission for Fisheries, 2011).

In the table Time frame: S = short, M = medium and L = long; Priority: H = high, M = medium and L = low. The term "National" refers to national government.

**APPENDIX 5**

## Concept notes for pilot projects for marine fisheries and aquaculture[1]

### Regional spatial planning projects

- Marine spatial planning in marine waters for Qatar and three neighbouring countries
- Provision of GIS training for personnel from RECOFI member countries as required
- Identification of potential areas for marine aquaculture in RECOFI waters

### National spatial planning projects[2]

Marine fisheries projects

| | |
|---|---|
| • Bahrain | Fishing effort distribution in the EEZ of Bahrain |
| • Iran (Islamic Republic of) | No project was submitted |
| • Iraq | Identification of protected habitats for some commercially important species in the EEZ of Iraq |
| • Kuwait | No project was submitted |
| • Oman | Identify the cause of kingfish decline in the EEZ of Oman |
| • Qatar | Identification of nursery grounds for demersal species in the western waters of Qatar |
| • Saudi Arabia | Mapping the fishing effort of shrimp fishery in the Al Qatir area |
| • United Arab Emirates | Identification of spawning habitat of demersal species in the EEZ of the United Arab Emirates |

Aquaculture projects

| | |
|---|---|
| • Bahrain | Identification of potential sites for the development of fish aquaculture in Bahrain |
| • Iran (Islamic Republic of) | No project was submitted |
| • Iraq | Identification of potential sites on the Iraqi coast for a marine fish hatchery to produce fry for restocking of Iraqi waters and marine recirculation farm to on-grow to market size for human consumption in the future. |
| • Kuwait | No project was submitted |
| • Oman | Integrated coastal planning and management of mariculture development in Oman |
| • Qatar | Identification of suitable sites for mariculture in territorial waters of Qatar |
| • Saudi Arabia | Identification of sites for mariculture in Saudi Arabian areas in the Gulf, e.g. Ras Abo |
| • United Arab Emirates | Identification of potential aquaculture sites to avoid/minimize effects of red tides. |

[1] This is a tentative list of pilot projects based on responses from the RECOFI country representatives, but it has been recommended that some of the projects should be changed in order to suit current RECOFI country capabilities in terms of present GIS capacity including data requirements (see p. 96–97).

[2] National spatial planning projects were presented in the draft report distributed to workshop participants and RECOFI focal points, whereas regional spatial planning projects were also discussed at the workshop in Cairo but were drafted after the workshop and therefore not distributed at the workshop.

**APPENDIX 6**

## Interim work and agency responsibilities

During the final workshop session, a proposed list of future activities and actions required to complete the proposal for a Development Programme for Implementing a Strategy on Spatial Planning for Marine Capture Fisheries and Aquaculture in RECOFI member countries, and the agencies responsible for completing each task, was discussed and agreed along with a proposed time frame.

| Activities | Responsibility | | | Time frame |
|---|---|---|---|---|
| | FAO | WGA/ WGFM | Countries | |
| Finalization of the concept notes for pilot projects | x | x | x | January–April 2013 |
| Budget estimate for Development Programme | x | | | April 2013 |
| Finalization of the Development Programme | x | | | May 2013 |
| Distribution of the Development Programme to workshop participants for final comments | | x | x | May 2013 (1 week for comments) |
| Presentation of discussion document of workshop report to seventh session of RECOFI | x | | | May 2013 |
| Finalization of the workshop report | x | | | June–August 2013 |
| Printing of workshop report | x | | | September 2013 |
| Distribution of workshop report to participants of RECOFI | x | | | October 2013 |
| **Intersessional activities at national and regional levels** | | | | |
| The production of leaflets/pamphlets by which to disseminate to higher- and middle-level decision-makers the necessary facts concerning spatially based planning and management. | x | | | From October 2013 to RECOFI meeting in 2015 |
| Exploring the structures necessary for implementing a Gulf Marine Spatial Plan, e.g.<br>• Highest-level communications and discussions to agree on need for MSP principles of working at country-wide and then RECOFI-wide scale<br>• Seek advice from various bodies as to what MSP adoption will involve<br>• Explore the relevant marine associated agencies in each country and identify specific stakeholders and participants<br>• Identify optimum working and committee structures<br>• Finalize working and legal structures in order to implement an MSP working environment (see concept note on "Marine spatial planning in marine waters for the State of Qatar and three neighbouring countries" in Annex 1 of Appendix 9). | x | x | x | From October 2013 to RECOFI meeting in 2015 |

| Activities | Responsibility | | | Time frame |
|---|---|---|---|---|
| | FAO | WGA/ WGFM | Countries | |
| A spatial planning familiarization workshop for middle-level decision-makers (technical and fishery managers). One-week workshop in a RECOFI country. Workshop for 16 attendees. | x | x | x | From October 2013 to RECOFI meeting in 2015 |
| Identify and appoint a "regional fisheries/aquaculture GIS champion" to optimize GIS progress across all RECOFI countries. Identify a "national fisheries/aquaculture GIS champion", plus location (or locations) where the GIS will be based, and establish a national GIS fisheries/aquaculture committee. | | x | x | From October 2013 to RECOFI meeting in 2015 |
| Locate and acquire all potentially useful data sets. Set up a suitable database management system for this. Ensure the data are suitably edited and up-to-date. Identify obvious missing data sets and make plans to secure them. | | x | x | From October 2013 to RECOFI meeting in 2015 |
| Provide practical GIS-based training as necessary to GIS operatives. One week of practical GIS training in a RECOFI country for 12 people (average of 2 persons from each of 6 RECOFI countries) – see concept note on "Provision of GIS training for RECOFI member countries personnel as required" in Annex 1 of Appendix 9. | x | x | x | From October 2013 to RECOFI meeting in 2015 |

*Note:* The intersessional activities would need to be adopted at a RECOFI session and funding would need to be made available.

**APPENDIX 7**

## Budget summary estimate for the Spatial Planning Development Programme

### Cost estimates for pilot projects for marine fisheries and aquaculture

| No. | Regional spatial planning projects | Costs (US$) |
|---|---|---|
| 1 | Marine spatial planning in marine waters for Qatar and other neighbouring countries | 125 000 |
| 2 | Provision of GIS training for personnel of RECOFI member countries as required | 128 240 |
| 3 | Identification of potential areas for marine aquaculture in RECOFI waters | 130 000 |
| | Subtotal | **383 240** |
| | **National spatial planning projects** | |
| | **Marine Fisheries** | |
| 1 | Bahrain | 32 000 |
| 2 | Iran (Islamic Republic of) | 24 000 |
| 3 | Iraq | 34 000 |
| 4 | Kuwait | 24 000 |
| 5 | Oman | 34 000 |
| 6 | Qatar | 24 000 |
| 7 | Saudi Arabia | 32 000 |
| 8 | United Arab Emirates | 34 000 |
| | Subtotal | **238 000** |
| | **Aquaculture** | |
| 1 | Bahrain | 60 000 |
| 2 | Iran (Islamic Republic of) | 0 |
| 3 | Iraq | 37 500 |
| 4 | Kuwait | 0 |
| 5 | Oman | 60 000 |
| 6 | Qatar | 85 000 |
| 7 | Saudi Arabia | 60 000 |
| 8 | United Arab Emirates | 90 000 |
| | Subtotal | **392 500** |
| | | |
| | **Total** | **1 013 740** |

*Notes:*
There are zero costs for Iran (Islamic Republic of) and Kuwait because no projects were submitted or proposed by these countries.

**Total cost estimates for the Development Programme to be shared among RECOFI member countries**

| Programme topics | Start-up costs (US$) | | Running costs (US$) | |
|---|---|---|---|---|
| | Minimum | Maximum | Minimum | Maximum |
| **1. Overseeing fisheries and aquaculture GIS work** | 135 000 | 135 000 | 10 000 | 10 000 |
| **2. Capacity building for higher-level decision-makers** | 65 000 | 65 000 | 10 000 | 10 000 |
| **3. Prioritizing GIS work and identifying pilot projects** | 490 000 | 850 000 | 320 000 | 640 000 |
| **4. Where, and how, will the GIS function best?** | 20 000 | 80 000 | 30 000 | 100 000 |
| **5. Practical training in GIS** | 100 000 | 130 000 | 10000 | 10000 |
| **6. Identifying and acquiring data for GIS** | 50 000 | 100 000 | 100 000 | 200 000 |
| **7. Updating and managing GIS data and information** | 80 000 | 80 000 | 80 000 | 80 000 |
| **Total** | **940 000** | **1 440 000** | **560 000** | **105 0000** |

*Notes:*

- Start-up costs and running costs are total figures for all eight RECOFI countries for each topic.
- Costings shown in Programme Topic 3 include the costs of conducting the pilot projects.
- Running costs are either total costs for some period in which the development programme will last (e.g. most pilot projects last two years) and annual costs (e.g. practical training on GIS will need to be done on a yearly basis).

**Average cost estimates for the Development Programme for each RECOFI member country**

| Programme topics | Start up costs (US$) | | Running costs (US$) | |
|---|---|---|---|---|
| | Minimum | Maximum | Minimum | Maximum |
| **1. Overseeing fisheries and aquaculture GIS work** | 16 875 | 16 875 | 1 250 | 1 250 |
| **2. Capacity building for higher-level decision-makers** | 8 125 | 8125 | 1 250 | 1 250 |
| **3. Prioritizing GIS work and identifying pilot projects** | 61 250 | 106 250 | 40 000 | 80 000 |
| **4. Where, and how, will the GIS function best?** | 2 500 | 10 000 | 3 750 | 12 500 |
| **5. Practical training in GIS** | 12 500 | 16 250 | 1 250 | 1 250 |
| **6. Identifying and acquiring data for GIS** | 6 250 | 12 500 | 12 500 | 25 000 |
| **7. Updating and managing GIS data and information** | 10 000 | 10 000 | 10 000 | 10 000 |
| **Total** | **11 7500** | **180 000** | **70 000** | **131 250** |

*Notes:*

- There will be significant variations in these costs between countries, i.e. largely as a function of the size of their EEZs and the future potential for fishery/aquaculture production.
- Running costs are either total costs for some period in which the development programme will last (e.g. most pilot projects last two years) and annual costs (e.g. practical training on GIS will need to be done on a yearly basis).

**Explanatory notes for budget estimates**

These budget estimates provide valuable guidance to RECOFI member countries. However, they are approximate estimates that were difficult to derive because there was a lack of feedback from RECOFI member countries and because member countries would be starting from very different baselines (e.g. their capacities for spatial analysis vary greatly).

"Start-up" costs assume that the GIS-based work is starting from scratch. There is also an assumption that it might take an average of one year to complete the pilot projects, although some might take longer – this depends on the amount of labour inputs and the period that data should cover. Moreover, work on other similar projects might be taking place at the same time as the pilot project work. Running costs are an estimated annual cost (or range of costs) that should cover GIS-based work into the future, i.e. after the first year.

1. Overseeing fisheries and aquaculture GIS work – Costs are approximate and difficult to estimate because they depend on what (and who) is included and for what length of time – a whole management structure would need to be established, formalized, and legally endorsed, and then it would need to be sustained. This cost includes a small proportion of the work undertaken by middle- and higher-level management. A cost–benefit analysis should exhibit considerable social, economic and environmental gains from this work). Costs include the concept note on "Marine spatial planning in marine waters for the State of Qatar and three neighbouring countries".

2. Capacity building for higher-level decision-makers – Costs would need to include only senior fisheries/mariculture personnel, but capacity building would be needed throughout all marine sectors. Capacity building costs would significantly reduce over time. Costs include the concept note on "Provision of GIS training for RECOFI member countries personnel as required".

3. Prioritizing GIS work and identifying pilot projects – The pilot projects themselves have been budgeted at US$30 000–60 000 for each country. A total of 17 pilot projects are proposed. The start-up costs include all labour costs plus a small amount for the initial hardware and software and an amount for buying the required data. The running costs include only labour costs on an annual basis for all eight RECOFI countries. This figure would vary greatly from country to country. Pilot projects for marine fisheries are more basic than those proposed for aquaculture, so they would cost considerably less to do. Costs include the concept note on "Identification of potential areas for marine aquaculture in RECOFI waters".

4. Where, and how, will the GIS function best? – The budget assumes some start-up costs and annual operating costs – these costs would be significantly higher for larger countries. The start-up costs include making accommodation and facilities available for the GIS-based work plus a small range of other initial system implementation costs. The running costs include replacement hardware and software, servicing, technical advice, ongoing accommodation costs, etc.

5. Practical training in GIS – The cost depends on the starting situation and the numbers trained. A basic level of expertise is assumed for all employees. The figures give mean costs for a medium-sized country, and all training costs would reduce over time.

6. Identifying and acquiring data for GIS – Initial costs may be high depending on needs and data sources – a typical range of mean annual costs is given – but countries with smaller EEZs could incur significantly lower costs. Costs could be significantly increased if specific marine data have to be obtained, e.g. for annual at-sea surveys of marine species.

7. Updating and managing GIS data and information – Estimated costs for all RECOFI countries. These would vary considerably from country to country.

**APPENDIX 8**

## RECOFI Spatial Planning Development Programme for Marine Capture Fisheries and Aquaculture. Questionnaire Survey Analysis Report

### Section 1. Status of implementation of elements of the regional programme

**Summary of results**

For all RECOFI countries, Table A8.1 shows their progress towards the implementation of a regional marine spatial planning (MSP) programme designed to manage all RECOFI marine waters in a sustainable way. The "Regional Programme Elements" form a hierarchy of activities designed to best ensure success for spatial planning via the use of geographical information systems (GIS).[1] Table A8.1 reveals that about 60 percent of all the elements for all RECOFI countries are only at an initial "Discussion" stage, 22 percent of elements have been "Initiated" to some extent, and 18 percent of the elements have been implemented. It is suspected that this implementation and/or initiation is at a national rather than a regional level. Three countries – Iraq, Kuwait and Oman (aquaculture) – are mainly at the discussion stage for most elements. Only Qatar has made fairly significant advances through the element implementation hierarchy. Other countries (Bahrain, Iran [Islamic Republic of], Saudi Arabia and Oman [Fisheries]) exhibit a very mixed (and varied) pattern regarding the implementation of the various elements. Generally, most progress has been made on implementing those elements directly involving GIS systems or related data, and least progress has been made on adopting elements that relate to regional working practices.

**Analysis**

The "Elements" referred to in this section are those established as stages in the proposed regional programme for implementing spatially based planning as a means of best managing marine capture fisheries and aquaculture in the Gulf waters of the RECOFI countries. Table A8.1 lists all 12 elements established and subsequently described in FAO (2011). It should be initially stated that the instructions in the survey questionnaire for Section 1 are open to two variable interpretations. Thus, respondents were asked: "Please indicate which **Elements** of the proposal for a Regional Programme for Implementing a Strategy on Spatial Planning for Marine Capture Fisheries and Aquaculture in RECOFI member countries have been implemented, initiated and/or discussed within your countries or in a regional context". It might be reasonably assumed that some answers will refer to "within your country" while others might be referring to "in a regional context". Although the following analysis assumes an either/or approach, it is considered that the vast majority of the responses will be with reference to a national rather than an inter-regional approach.

The status with respect to implementing marine spatial planning within a national or regional context is variable from country to country, although, generally, planning is not well advanced. Thus, of a total of 96 possible responses (8 countries[2] × 12 elements each), 59 show that spatial planning elements have only reached the discussion stage. In two countries (Iraq and Kuwait), it appears that MSP has not moved beyond the discussion stage at all, and indeed it is possible that any such planning discussions have only been initiated in response to the Doha 2010 RECOFI workshop activities (and their follow-up tasks). However, Iraq and Kuwait have rather limited marine waters in the Gulf and, thus, they might not perceive a need for these marine areas to be regionally managed. With respect to aquaculture, Oman too has not moved much beyond a discussion phase, probably because there is little current need for this activity.

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[1] The elements are described in detail in: FAO. 2011. *Report of the Regional Technical Workshop on Spatial Planning for Marine Capture Fisheries and Aquaculture. Doha, the State of Qatar, 24–28 October 2010*. FAO Fisheries and Aquaculture Report No. 961. Rome. 118 pp. (also available at www.fao.org/docrep/014/i2054e/i2054e00.pdf).

[2] This is actually seven countries but the United Arab Emirates did not submit a completed questionnaire, and Oman submitted two questionnaires (one for fisheries and one for aquaculture).

The country that has made significant moves towards the spatial management of its marine waters is Qatar. According to the survey results, 5 of the 12 elements making up the entire marine regional spatial planning strategy have already been implemented (Elements 2, 3, 4, 6 and 10), although it is believed that this implementation is mainly at a country level only. In fact, there is evidence of only one regional approach having been made, i.e. with Qatar and Bahrain both noting that they have implemented "Legislation and Regulation" at the inter-regional level. Given their very close proximity, this is quite likely. The fact that Qatar has only "discussed" Element 11 ("system requirements, design, procurement and testing") is difficult to understand as it claims to have already implemented some aspects of GIS.

In four countries, the picture with respect to spatially based marine management is very mixed, i.e. in Bahrain, Iran (Islamic Republic of), Saudi Arabia and for fisheries in Oman. Each of these countries has made clear movements forward in certain (although rather different) elements. Oman has been quite strong in at least initiating some elements with respect to the spatial management of its fisheries. This almost certainly relates to the high importance of fisheries in this country compared with the other three and, thus, the perceived need to implement these strong management practices.

Examining Table A8.1 in terms of those elements where there has been most progress towards implementation, there is not much variation. Overall, the provision of GIS training among the countries is relatively strong, as too are the elements relating to "identifying GIS-based pilot projects", "data collection and storage" and to work on "legislation and regulation". This probably indicates a degree of familiarity and involvement with GIS generally and the perception that GIS/spatially based management might be worth trying as a management option. Least overall progress with respect to implementing the elements has been seen in "Continuity of the GIS capacity within the Strategy". This is not surprising as this element can only really be practised once a fisheries/aquaculture GIS has been implemented. Other elements on which the least amount of progress has been achieved are "regional policy and marine spatial planning", "regional and national cooperation and networking" and "system design, procurement and testing". Again, it is not surprising that little emphasis has been placed on these elements to date, mainly because this whole regional spatially based programme has not progressed far along its implementation path.

**Table A8.1**

Status of implementation of elements of the Regional Programme

| Regional Programme Elements | Country | | | | | | | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Bahrain | | | Iran (Islamic Republic of) | | | Iraq | | | Kuwait | | | Oman (aquaculture) | | | Oman (capture fisheries) | | | Qatar | | | Saudi Arabia | | | United Arab Emirates | | |
| | 1 | 2 | 3 | 1 | 2 | 3 | 1 | 2 | 3 | 1 | 2 | 3 | 1 | 2 | 3 | 1 | 2 | 3 | 1 | 2 | 3 | 1 | 2 | 3 | 1 | 2 | 3 |
| 1. Regional policy and marine spatial planning | | | X | | X | | | | X | | | X | | | X | | | X | | X | | | | X | | | |
| 2. National needs and national GIS/RS related capacities | | X | | | | X | | | X | | | X | | | X | | X | | X | | | | | X | | | |
| 3. Legislation and regulation | X | | | | | X | | | X | | | X | X | | | | | X | X | | | | | X | | | |
| 4. Regional and national cooperation and networking | | X | | | | X | | | X | | | X | | | X | | X | | X | | | | | X | | | |
| 5. Awareness building and promotion of spatial planning to non-GIS specialists | | | X | | X | | | | X | | | X | | | X | | X | | | | X | | X | | | | | |
| 6. Regional or national basic training in GIS | | | X | X | | | | | X | | | X | | | X | X | | | X | | | | X | | X* | | |
| 7. GIS project management | | | X | X | | | | | X | | | X | | | X | | X | | | X | | | X | | X* | | |
| 8. Identifying GIS-based pilot projects and their data needs | | X | | | | | | | X | | | X | X | | | X | | | | | | X* | | | X* | | |
| 9. Continuing data collection and storage | X | | | | X | | | | X | | | X | | X | | | | X | | X | | | X | | | | |
| 10. Integration of GIS-related information and publications databases | | X | | | | X | | | X | | | X | | | X | | | X | X | | | | | X | | | |
| 11. System requirements, design, procurement and testing | | | X | | X | | | | X | | | X | | | X | | X | | | | X | | | X | X* | | |
| 12. Continuity of the GIS capacity within the strategy | | | X | | | X | | | X | | | X | | | X | | X | | | | X | | | X | | | |

* Status inferred from information in addition to survey responses.

*Note:* 1 = implemented; 2 = initiated; 3 = discussed.

## Section 2. Identification of GIS-based pilot projects and their data needs

### Summary of results

This section refers to Element 8 (see p. 101 in footnote 1) and is concerned with the identification of GIS-based pilot projects and their data needs. The questionnaire responses identified the number and type of GIS-based projects undertaken by countries in the RECOFI region. This allowed for the analysis of types of GIS project undertaken, the lead agency involved and the data types collected. This information will allow the identification of potential GIS-based projects, thus avoiding duplication of previous work, and will help to prioritize projects designed to address fisheries and aquaculture planning and management needs.

The questionnaire survey revealed that 12 fisheries and aquaculture projects had been, or were being, undertaken and that they had a wide range of data needs. Most projects were in the fisheries management sector, or in vessel control and environmental data analysis. The aquaculture projects were primarily aimed at identifying suitable sites for aquaculture development but also for the development of a database of existing farm locations The government departments leading the projects were primarily from the fisheries and aquaculture sector or from environmental agencies. The majority of fisheries GIS projects tended to be multidisciplinary and had a wide range of data needs.

Most capture fisheries GIS projects identified by countries (Table A8.2b) were for those associated with “fishing fleet disposition and behaviour”, and for “monitoring management of fishing effort or enforcement policies”. Equally, there were project and data needs for “ecosystems approaches to management” where GIS is probably seen as a useful tool. Few countries proposed doing GIS work on either “stock enhancement” or looking at “ecosystems relationships”. The information shown in Table A8.2b should be viewed with caution because four of the countries intended to do almost no GIS work on any the thematic areas shown, whereas Bahrain, Iraq and Qatar intend to do work on almost every thematic area.

The majority of GIS projects in aquaculture (Table A8.2c) are likely to be aimed at the “development of aquaculture” although projects aimed at various aspects of aquaculture management were also favoured by half the RECOFI countries (Bahrain, Iraq, Kuwait and Qatar). For many RECOFI countries, aquaculture development is seen as a new and important sector that can utilize coastal resources.

### Analysis

This element of the proposed Regional Programme attempts to identify GIS-based projects in the member counties that are either planned, or can be replicated or readily supported, i.e. applying to either marine capture fisheries or to aquaculture.

Table A8.2a shows that all the countries except Kuwait identified suitable GIS-based projects. In total, 11 projects [1] were identified, ranging from Oman with 4 projects to Qatar and the United Arab Emirates with 1 project each. The majority of the projects (54.5 percent) were at a planning stage; those suggested by Oman appeared to be in progress, those mentioned by Iran (Islamic Republic of) and by Saudi Arabia had already been completed, and Kuwait had not identified a suitable GIS project. Most of the projects (72.7 percent) were in the fisheries sector. Topics being covered ranged from the establishment of a capture fisheries database to monitoring vessel movements, fisheries resource assessments, sustainable fisheries management and water-quality data collection.

The aquaculture projects were primarily aimed at identifying suitable sites or zones for aquaculture development. Three countries had exclusively fisheries projects, two countries exclusively aquaculture project and only Oman had a mix of fisheries and aquaculture GIS projects. The government agencies leading the projects were primarily fisheries and aquaculture agencies (81.8 percent) and environmental agencies (18.2 percent).

[1] The inland fisheries project identified in Iraq is relevant for spatial planning, but it is beyond the mandate of RECOFI, whose focus is on marine resources. Accordingly, the inland fisheries project is not included in the analysis of Table A8.2a.

**Table A8.2a**
GIS-based pilot projects that are planned or could be supported in either marine capture fisheries or in aquaculture

| Country | General comments / project titles |
|---|---|
| Bahrain | The General Directorate for the Protection of Marine Resources in association with the GIS Directorate, Central Informatics & Telecommunications Organisation (CITO) has already embarked on a "GIS project" to collate all spatial information available with the Public Commission for Protection of Marine, Environment, & Wildlife (PMEW, including the Fisheries and Marine Resources Directorate). The spatial information is presented via a customized web application for query and analysis. A large volume of marine capture fisheries data has been produced during the Marine GIS (MarGIS) Project, which is an online marine environmental GIS. The presentation of this project has been provided in a separate file. The current application attempts to bring all these data and information into a uniform platform for further use and analysis by PMEW users. |
| Iran (Islamic Republic of) | The Islamic Republic of Iran has already implemented a web-based Fisheries Marine Information System (FMIS). This system is available online (http://nezarat.fisheries.ir). A national fishing ports GIS-based database has also been implemented (http://fisheries.ir/web_system/start_local.aspx – see also page 5 of the report of the FAO Technical Workshop on Spatial Planning for Marine Capture Fisheries and Aquaculture, Doha, 24–28 October 2010). |
| Iraq | The United Nations Development Group Iraq Trust Fund – Project A5-23 was titled "Towards sustainable development of **inland** fisheries in Iraq". This project was managed by FAO and the Iraqi Ministry of Agriculture. The major GIS output is available at http://mdtf.undp.org/document/download/2620<br>The actual physical implementation of this inland fisheries project has not yet occurred, and the trainees are no longer employed with the Ministry of Agriculture. |
| Kuwait | No projects identified. |
| Oman (for aquaculture) | At the Doha 2010 RECOFI workshop, Oman mentioned that four relevant spatial planning/GIS projects had been initiated or conducted. The one relevant to aquaculture was to compile an atlas entitled "Atlas of suitable sites for aquaculture projects in Oman". The atlas contained satellite imagery and information relevant for site selection / suitability studies for aquaculture. The atlas was to be made available on www.mofw.gov.om |
| Oman (for capture fisheries) | At the Doha 2010 RECOFI workshop, Oman mentioned that four relevant spatial planning / GIS projects had been initiated or conducted. Three related to capture fisheries: (i) a vessel tracking monitoring system (VMS) for commercial fishing vessels; (ii) a fish resources assessment survey to provide spatial habitat information; and (iii) collection of available remote-sensing data such as SST, currents, Chl-*a*. |
| Qatar | The project titled "Sustainable Management of Fisheries Resources" aims to implement an ecosystem approach to fisheries and marine resources in Qatar by establishing an infrastructure for effective ecosystem-based fishery management in accordance with the Code of Conduct for Responsible Fisheries (FAO, 1995). Qatar considers that, given the complexity and dynamic nature occurring between fisheries and ecosystems, there is currently insufficient biological and ecological knowledge/data concerning the ecosystems in which fisheries operate in Qatar. Therefore, the project's expected outcomes will have significant strategic importance at the national level by systematically building capacity at the institutional level to ensure key ecosystem principles are being implemented and sustained for the long-term benefit of the marine ecosystem. A project details sheet was provided. |
| Saudi Arabia | Saudi Arabia has conducted a project titled "Identification of potential aquaculture zones along the Red Sea coast of the Kingdom of Saudi Arabia using satellite image analysis and GIS and an estimate of sustainable carrying capacity". The study, undertaken in early 2011, considered both land- and sea-based aquaculture. A summary sheet of this project has been prepared and circulated as an example to RECOFI contacts along with this survey.*<br>Saudi Arabia has also developed a database on locations of fish farms together with attribute information using a Google Earth application. An online vessel tracking and monitoring system was indicated as a proposed project during the 2010 RECOFI spatial planning workshop.* |
| United Arab Emirates | The Environment Agency of Abu Dhabi has identified a project and released a "Request for Proposals" for a study that includes an identification of suitable aquaculture development zones, exclusion zones, and ecological significance zones.*<br>The project includes stakeholder engagement and capacity building within the Environment Agency. The GIS database of the Environment Agency would be the primary source of spatial data.<br>The specific status of this project would need to be confirmed by either the Environment Agency for Abu Dhabi or the national RECOFI focal point. The current status in the United Arab Emirates other than Abu Dhabi is unknown at present. |

* Status inferred from information in addition to survey responses.

Tables A8.2b and A8.2c require that countries select the thematic areas that might be addressed by either future GIS projects in fisheries or aquaculture, respectively. From Table A8.2b, it appears that RECOFI countries have taken contrasting approaches to their future GIS project work in fisheries. Three (Bahrain, Iraq and Qatar) have indicated (or foreseen) that they might wish to undertake projects

covering at least ten of the suggested thematic areas. This might be a pragmatic view insofar as there is always a possibility that they might need to accomplish any of this work in the future. In contrast, Oman has suggested that three of the thematic areas might be of interest to their fishery objectives, but the other four RECOFI countries have only suggested that either one thematic area would be of interest, or that no areas are of interest. Those countries not expressing any interest either did not complete the questionnaire (the United Arab Emirates) or possibly had yet to come to any decision on this.

Those thematic areas appearing to be of most interest for GIS projects were “fishing fleet disposition and behaviour”, i.e. to ensure that fishing vessels need to be optimally deployed throughout a management or ecosystem area to best sustain fish yields (five countries), and “monitoring, management or enforcement policies”, i.e. perhaps via the use of electronic logbooks or VMS-based tracking systems (four countries). Of the other eight suggested fisheries GIS project areas, none was selected by more than three countries although the distribution of selected themes was quite even between countries. Taken together, there seems to be an indication that RECOFI countries show an interest in a wide range of fisheries GIS work.

**Table A8.2b**

Identification of thematic areas to be addressed by GIS-based pilot projects in marine capture fisheries

| Country | Distribution displays | Marine habitat mapping and analyses | Modelling | Monitoring, management or enforcement policies | Ecosystem relationships | Stock enhancement | Marine zoning and reserve allocation | Creation of economic surfaces | Fishing fleet disposition and behaviour | Ecosystem approaches to management | Other |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Bahrain | X | X | X | X | X | X | X | X | X | X | |
| Iran (Islamic Republic of) | | | | X | | | | | | | |
| Iraq | X | X | X | | X | | X | X | X | X | Exchanging information about fishing zone, species, total capture, depths. |
| Kuwait | | | | | | | | | | | Marine spatial planning for efficiently managing its marine capture fisheries and aquaculture (with assistance from RECOFI/FAO). |
| Oman | | X | | X | | | | | X | | |
| Qatar | X | | X | X | | X | X | X | X | X | |
| Saudi Arabia | | | | | | | | | X* | | |
| United Arab Emirates | | | | | | | | | | | |

Turning to aquaculture-based GIS projects (Table A8.2c), two countries (Bahrain and Iraq) expressed an interest in all GIS thematic areas; Kuwait showed an interest in three of the four areas; Qatar showed an interest in two areas; and the remaining countries in one area or in no areas (Iran [Islamic Republic of]). Again, some countries may be "keeping their options open", while other countries see that GIS might only be applied for aquaculture purposes in very limited ways. The responses from Iraq may be concerned with inland aquaculture.

The majority of GIS projects were perceived by countries as being useful for the "development of aquaculture", where GIS can be used for estimating aquaculture potential, assessing the suitability of sites and carrying out zoning, strategic planning for development, as well as for anticipating the consequences of aquaculture (environmental, social and economic impacts). For some RECOFI countries, aquaculture development is seen as a new and important sector that can utilize coastal resources. Fewer countries identified the utility of using GIS in aquaculture for "aquaculture practice and management" or for "multisectoral development and management that includes aquaculture". Only two countries (Bahrain and Iraq) identified the potential use of GIS for "training and promotion of GIS". This may be due to the fact that many countries have already identified IT or GIS departments within the aquaculture and fisheries line agencies or environmental agencies. Additional comments were provided by Iran (Islamic Republic of), but these were not directly related to GIS projects, and by Kuwait, whose comments could have been included under the heading of "the development of aquaculture".

**Table A8.2c**

Identification of thematic areas to be addressed by GIS-based pilot projects in aquaculture

| Country | Training and promotion of GIS | Development of aquaculture | Aquaculture practice and management | Multisectoral development and management that includes aquaculture | Other |
|---|---|---|---|---|---|
| Bahrain | X | X | X | X | |
| Iran (Islamic Republic of) | | | | | The FMIS referred to in Table A8.2a collects aquaculture and fishery statistics by region. |
| Iraq | X | X | X | X | |
| Kuwait | | X | X | X | By application of suitable spatial planning tools, Kuwait prefers to estimate its aquaculture potential, assessing suitable sites for aquaculture, conceptualizing a strategic plan for aquaculture development, and to mitigate the potential consequences, such as environmental, social and economic impacts, from its aquaculture development. |
| Oman | | X | | | |
| Qatar | | X | | X | |
| Saudi Arabia | | X* | X* | | |
| United Arab Emirates | | X* | | | |

* Status inferred from information in addition to survey responses.

## Section 3. Continuing data collection and storage

**Summary of results**

This section addresses Element 9, which is concerned with continuing data collection and storage for GIS purposes. Thus, it is important to identify the existing data sets, the type of data currently being collected, the data storage systems, and aspects and possibilities of sharing of data.

Most countries reported having a programme of continuing spatial data and information collection and storage. The information and data were usually being collected by the line agency for fisheries and aquaculture as well as by specialized GIS departments and the environmental agency. The data being collected by RECOFI countries were very variable in range. In most countries, a range of data is collected systematically, and this is frequently what may be perceived as general fisheries or aquaculture data, e.g. data on fisheries and fish stocks, periodic collection of data on fish biomass, landing locations and fishing effort per landing site, plus environmental data including those on water quality, temperatures, bathymetry as well as the collection of some socio-economic data. Other countries reported that, as well as general data being systematically collected, data were also collected for specific GIS projects, although this was not collected systematically. Although not reported by all countries, there is the collection of fisheries and aquaculture data as part of the FAO annual statistical data collection. Some countries collect data on aquaculture locations and on aquaculture companies.

Very little activity was noted with respect to the continued updating and editing of GIS data, and it was surmised that this was because most of the data were only ever likely to be used once. However, much of the more general marine, fisheries or aquaculture-based data ought to be the subject of more frequent editing and updating attention. Five of the eight RECOFI countries reported having database management systems (DBMS) in place, although there was little standardization between countries with respect to the DBMS being used.

There was a wide range of responses on data sharing, ranging from the systematic collection of data by all departments, data that were freely available to all other departments and sometimes to business sectors and to citizens. In other countries, any online data sharing has to be authorized by responsible offices using security codes for accessing. Some data are available only for specific users or projects. However, there is also some unwillingness to share data with other agencies. Sharing of data can result in substantial reductions in the cost of development and a curtailing of duplication of data collection, and future analysis and good practice would be to develop a “single, consistent, and accessible” government-funded infrastructure as a basis for developing competitive and value-added services.

**Analysis**

Examining Table A8.3a, all countries except Iraq and Kuwait reported that they had a programme of continuing spatial data and information collection and storage. However, the information and data were being collected by the line agency for fisheries and aquaculture as well as by specialized GIS departments and environmental agencies. The data being collected included data collected for fisheries management (Bahrain), for fisheries and aquaculture (Iran [Islamic Republic of]), and only for aquaculture (Saudi Arabia, the United Arab Emirates and Oman [planned]). In most countries, data are collected systematically, although in some countries (Oman, Saudi Arabia and the United Arab Emirates) it was reported that data were collected for specific projects.

In terms of the collection of data on fisheries and fish stocks, the United Arab Emirates reports that it undertakes periodic surveys of demersal fish biomass and fishing locations, while Bahrain collects data on fishing effort per landing site. Oman, Saudi Arabia and the United Arab Emirates collect data on fish landing site locations, and Oman has collected data on fishing vessel movements. Iran (Islamic Republic of) reports the collection of data about the registering of fishing vessels (basic registration and yearly registration), owners of fishing vessels and persons in charge of fishing, fishing methods, and fished species. It also collects geographical data about the routing and location of fishing vessels, fish capture data (such as quantity and quality) and data related to fishing violations.

For aquaculture, Saudi Arabia collects data on aquaculture locations; Iran (Islamic Republic of) collects data on aquaculture companies and as part of the FAO NASO maps project

(www.fao.org/fishery/nzso-maps/en). Iran (Islamic Republic of) has reported the locations of aquaculture projects to the province level. Iran (Islamic Republic of), Oman, Qatar and the United Arab Emirates report the collection of environmental data, with Oman and the United Arab Emirates collecting water-quality data. Qatar reports the additional collection of a range of socio-economic data. Thus, it can be seen that quite a wide variety of data is being collected. However, it is important to highlight that there is a sense in which data can be considered as being of two kinds: (i) general data relating to fisheries and/or aquaculture within the overall jurisdiction of a country; and (ii) data that are required for (or from) specific projects or surveys. The first of these data types is likely to have relatively widespread future usage (as long as the scale/resolution of the data is sufficient), while the second data type is unlikely to be used again. It is clear (from Table A8.3a) that none of the RECOFI countries is likely to have all the data needed (general or specific) for specific GIS-based fisheries or aquaculture projects. Most of the data recorded in Table A8.3a appear to be related to more general (i.e. non-fisheries) data (e.g. held by Bahrain), or data that have been collected for specific regions or projects. While all the data collected should be filed and carefully recorded and stored, it is clear that data collection will be a major consideration for guaranteeing the success of future project work.

Examining Table A8.3b, only Iran (Islamic Republic of) and Qatar reported mechanisms in place for conducting the post-collection activities of updating and editing data. Iran (Islamic Republic of) reports that data are edited by a scientific committee at national/provincial level. Qatar reports that data are updated depending on the speed of change in the data and scheduled surveys. A major reason for the lack of editing or updating is probably that, as many of the data being collected are project specific, they will probably not be worth updating for future use (and presumably any editing was carried out before they were originally used).

Table A8.3c shows that all countries except Iraq, Kuwait and Oman reported that there was some form of database management system in place or that this was planned. There is a range of database software and GIS software used with no standardization between countries. Two countries (Bahrain and Qatar) have specific GIS agencies or a framework for data management. Bahrain has a centralized agency (the “GIS Directorate” of the Central Informatics and Telecommunications Organisation [CITO]). In Qatar, data (mostly in GIS format) are collected by respective agencies depending upon data type and can be shared by all government agencies via high-speed fibre connections to a GIS-Net. Table A8.3d shows that there was a wide range of responses on data sharing. Qatar reported the systematic collection of data by all departments, data that are freely available to all other departments. Bahrain has the BSDI Portal, part of its National Spatial Data Infrastructure, which facilitates and co-coordinates the exchange and sharing of spatial data among stakeholders in government, business sectors and private citizens.

Iran (Islamic Republic of) reported that online statistics are available within the Fisheries Marine Information System. These contain large amounts of data about fisheries activities in the country, and can be a very useful basis for the implementation for GIS. However, sharing any data online must be authorized by responsible offices, and although data are made available on the Internet, users must have security codes for access. Some data are available only for specific users or projects, such as in Oman, which is proposing an aquaculture database that will not be available for the general public (only for aquaculture users), and in the United Arab Emirates, where the Environment Agency of Abu Dhabi has a GIS database that it is willing to make available for aquaculture zoning studies. In Saudi Arabia, it was reported that individual agencies had separate databases that they were unwilling to share with other agencies.

Data sharing can result in substantial reductions in the cost of development and help to curtail the duplication of data collection and analysis. Bahrain reports that an objective of its BSDI portal project is to emphasize the concept of a “single, consistent, and accessible” government-funded infrastructure as a basis for developing competitive value-added services as a contribution towards sustainable development. This endeavour reflects and promotes recommendations on the use of the corporate database concept to integrate GIS data for all units of local government that are participating, under the auspices of the NSDI, in a cooperative corporate GIS programme.

**Table A8.3a**

Continuing data collection and storage (are spatial data being collected?)

| Country | Spatial data and information being collected |
|---|---|
| Bahrain | The fisheries department collects monthly fish landings data regarding fishing gear/boat, fishing effort per landing site and other fisheries statistics.<br><br>The "GIS Directorate" of the Central Informatics & Telecommunications Organisation (CITO), in compliance with a government decree and directives of the National GIS Steering Committee (NGISSC), officially implemented a "National Spatial Data Infrastructure" (NSDI) for the country in February 2005. The "Bahrain Spatial Data Infrastructure" (BSDI) portal, a manifestation of the NSDI, is meant to fulfil the mandates of the NGISSC and, thereby, the NSDI. The BSDI portal operates on a GIS database of geospatial data layers that includes, but is not limited to:<br>o oil and gas infrastructure,<br>o cadastral,<br>o topographic,<br>o sewage,<br>o electricity transmission and distribution,<br>o water transmission and distribution,<br>o telecommunications,<br>o administrative boundaries,<br>o addresses,<br>o buildings,<br>o street centre-lines,<br>o points of interest (PoIs).<br>o satellite images (2005, 2006, 2009, 2010, 2011),<br>o demography (population),<br>o marine data sets; survey and land registration directorate. |
| Iran (Islamic Republic of) | Environmental, geographical, biometric and physical data have been collected in a database. A structure for the database has been assigned. Regulations for filling the database with raw data are within the control of the aquaculture and fishery deputies of the Iran Fisheries Organisation (IFO).<br><br>The information technology (IT) office of the IFO, in cooperation with aquaculture and fishery deputies, started (in 2010) to design a total information system (IS) for managing aquaculture and fisheries, i.e. after the 2010 Qatar workshop on spatial planning.<br><br>The IT office has designed two sub-information systems completely and has operated one of them (aquaculture IS) in three provinces of the country. The main aim of designing such systems is to collect and manage basic and fundamental data throughout the country for GIS and spatial planning purposes. The IT office is now designing a web-based and customized GIS and, after collecting all of the data in a database, they will migrate them as layers into maps. These two sub-ISs collect the following information:<br>o Aquaculture IS, the basis of information is that it belongs to the aquaculture unit (farm, complex, twin purpose agri-aqua ponds, etc.) including:<br>▪ A. Registration data of the aquaculture unit.<br>▪ B. Owner(s) of aquaculture units.<br>▪ C. Geographical and environmental data related to aquaculture units (location, water source [quality, quantity, etc.], climate, etc.).<br>▪ D. Construction and dimensional data for aquaculture units.<br>▪ E. Basic biometric data for the main cultured species in each unit.<br>▪ F. Extended biometric data for cultured species for each year.<br>▪ G. Complete production stats for each unit. |

| Country | Spatial data and information being collected |
|---|---|
| | o Fishery IS:<br>▪ A. Registration data for fishing vessels (basic registration and yearly registration).<br>▪ B. Owner(s) of fishing vessel and person(s) in charge of fishing.<br>▪ C. Fishing methods.<br>▪ D. Fish species caught.<br>▪ E. Geographical data about routing and location of fishing.<br>▪ F. Capture data (such as quantity, quality).<br>▪ G. Fishing violations related data.<br>o The system is in the FARSI language, designed by .NET framework and C# technology using MS-SQL 2008 Database. |
| Iraq | Currently, the relevant agencies of Iraq do have not access to any spatial data or persons with spatial data skills.<br>There are no data in a nearby or similar government organization within Iraq. |
| Kuwait | None. |
| Oman (for aquaculture) | Oman collects the following spatial data with respect to aquaculture:<br>o Water samples to check the quality of water and protect the aquaculture farms from E. coli bacteria.<br>o Water samples were collected for analysis of E. coli bacteria only. Salinity was recorded but not temperature.<br>o In the future, all physical parameters will be recorder, e.g. temperature, salinity and pH.<br><br>A potential future project being discussed (see Table A8.2a) would (if implemented) create a comprehensive database for all remote sensing and GIS data obtained for all aquaculture projects in different parts of Oman. The data to be compiled are:<br>o spatial distribution,<br>o type of habitats,<br>o biological factors,<br>o physical factors,<br>o chemical factors.<br>In addition to this, real-time data would be collected in order to make comparisons between satellite and real data.<br>The database will be completed after the end of each project in aquaculture; normally, each project takes 2–3 years to complete.<br>At the end of each project, it is intended to publish the data in a scientific report or scientific magazine and update the system of GIS on the website to allow scientists and researchers to understand how aquaculture can be developed in the future.<br>The first priority is to update data for GIS to develop and manage aquaculture in Oman. |
| Oman (for capture fisheries) | Oman collects the following spatial data with respect to capture fisheries.<br>a. Data collected continuously: oceanography data, VMS data.<br>b. Data collected for specific projects: Specific projects collect data that are relevant to that project. The project-based nature of this data collection means that it is not a permanent ongoing data collection exercise. For example, a project was carried out in 2010 for implementing GIS using fisheries data for a specific area. The project was undertaken in Muscat in a region named Quriyat. Several types of data were collected, including:<br>o fishing villages,<br>o landing areas,<br>o fishery categories,<br>o marine environmental data,<br>o data about sea depth,<br>o data about fishing industries,<br>o data about aquaculture companies. |

| Country | Spatial data and information being collected |
|---|---|
| Qatar | The 2010 RECOFI spatial planning workshop report states that "the GIS centre in the State of Qatar is well equipped with infrastructure, data, and technical personnel. …that could be of immediate use for fisheries and aquaculture related applications".*<br><br>Environmental, physical or statistical (socio-economic) data are collected by respective agencies in Qatar. Most of the data are in GIS format and can be shared by all governmental agencies connected to GIS-Net with high-speed fibre. Other relevant data not available on the network can be obtained from the respective departments. (Contact details for departments provided in original survey.) |
| Saudi Arabia | The initiations indicated in Table A8.1 have not yet been executed.<br><br>Available data from the project referred to in Table A8.2a have been stored in a spatial GIS database. (However, it is recognized that this database suffered from a reluctance of several government agencies to share spatial data for the project.) This database includes information such as land type, navigation routes, bathymetry, coastguard stations, administrative boundaries, topography, SST, salinity, and protected areas.* |
| United Arab Emirates | It is apparent that at least the Environment Agency of Abu Dhabi has a GIS database, which it is willing to make available to aquaculture zoning studies (see Table A8.2a). The specific content of that database is unknown, although it is likely to include general and useful spatial environmental information.*<br><br>SST and Chl-*a* data are available for the United Arab Emirates at www.moew.gov.ae *<br>Periodic surveys of demersal fish biomass, locations, physical water parameters along with censuses and monitoring of fish landing sites appear to be conducted (as mentioned at the RECOFI 2010 workshop).* |

* Status inferred from information in addition to survey responses.

**Table A8.3b**

Continuing data collection and storage (are there any post-collection activities?)

| Country | Post-collection activities for updating and editing spatial data and information |
|---|---|
| Bahrain | Besides project specific data, the Fisheries Department has been working on:<br>o stock enhancement programmes through releases of fry and fingerlings to help protect the local endangered marine resources from extinction;<br>o artificial reef projects;<br>o locations of barrier traps;<br>o projects on dredging areas in the sea for sand and reclamation areas;<br>o fish capture classification by species, fishing gear and fishing area and landing site. |
| Iran (Islamic Republic of) | Yes, all data gathered are edited by a scientific committee at national/provincial level |
| Iraq | None |
| Kuwait | None |
| Oman (for aquaculture) | None |
| Oman (for capture fisheries) | None (yes, for VMS) |
| Qatar | Different spatial data are collected by respective agencies, and all of them have an update mechanism in place. The updates are based on the intensity of temporal change and/or based on scheduled field surveys. |
| Saudi Arabia | None. |
| United Arab Emirates | No response. |

**Table A8.3c**

Continuing data collection and storage (is there a database management system?)

| Country | Database management systems |
|---|---|
| Bahrain | A database management system in the form of the Kingdom of Bahrain Spatial Data Infrastructure (BSDI) has already been implemented by the "GIS Directorate", CITO. The BSDI was built with an infrastructure conforming to the stipulations of ISO, OGC standards, Inc. and functions as a powerful indispensable tool for economic, social development and environmental management, enabling the full potential of GIS technology. |
| Iran (Islamic Republic of) | Yes, an SQL SERVER 2008 has been procured for the same purpose (see Table A8.3a). |
| Iraq | None. |
| Kuwait | None. |
| Oman (for aquaculture) | Yes, at the project proposal level, not at a more general level.<br>The database will be stored on the server at the aquaculture centre; this will be a "reference point" for all projects at the aquaculture centre. |
| Oman (for capture fisheries) | None. |
| Qatar | Most agencies use RDBMS and the ESRI suite of GIS software for managing their respective spatial and non-spatial data, and follow their own policies towards data storage and security. |
| Saudi Arabia | Available data from the project referred to in Table A8.2a has been stored in a spatial GIS database providing a useful platform for future studies.* |
| United Arab Emirates | It is apparent that at least the Environment Agency of Abu Dhabi has a GIS database, which they are willing to make available for aquaculture zoning studies (see Table A8.2a).* |

* Status inferred from information in addition to survey responses.

**Table A8.3d**

Continuing data collection and storage (can spatial data be easily shared?)

| Country | Sharing of spatial data |
|---|---|
| Bahrain | BSDI Portal, a manifestation of the National Spatial Data Infrastructure (NSDI), facilitates and co-coordinates the exchange and sharing of spatial data among the stakeholders in Government, Business Sectors and Citizens (G2G; G2B and G2C), resulting in substantial reductions in the cost of development and curtailing of the duplication of data. One of the objects of this project is to emphasize the concept of a "single, consistent, and accessible", government-funded infrastructure as a basis for developing competitive and value-adding services leading towards sustainable development. This endeavour reflects and promotes recommendations for the use of the corporate database concept to integrate GIS data for all units of local government that are participating in a cooperative corporate GIS programme, under the auspices of the NSDI. |
| Iran (Islamic Republic of) | Table A8.2a refers to the online statistics available within the Fisheries Marine Information System, although it is unclear if this relates to environmental-type data or (more probably) fisheries catches or aquaculture production within regions.<br>Sharing any data online must be authorized by responsible offices. Data are on the Internet, but users must have security codes for accessing. The two ISs (see Table A8.3a) contain huge amounts of data about fisheries activities in the country, which could be very useful base for the implementation of GIS. |
| Iraq | Not applicable. |
| Kuwait | Not applicable. |
| Oman (for aquaculture) | Spatial data cannot be easily shared at present in general, although at the project proposal level, there is sharing and coordination.<br>The proposed database (see Table A8.2a) will not be for the general public, only for aquaculture users.<br>The system built for GIS will have a password, so access will be only available for purchase.<br><br>Table A8.2a refers to an atlas of suitable sites for aquaculture projects in Oman that utilized spatial data. This atlas was to be made available on www.mofw.gov.om |
| Oman (for capture fisheries) | Not applicable. |
| Qatar | Qatar considers itself to be perhaps the only country in the world with nationwide GIS. This means that all governmental organizations in the country are connected with a high-speed network (GIS-NET) wherein the GIS data are shared with one another. If there are data that are not shared on the network, and if some other government agency needs them, the agency always request the data, justifying the need. |
| Saudi Arabia | A reluctance to share spatial data was a hindrance for the study described in Table A8.2a. The database created for that study was therefore forced to use largely freely available data. It is notable that this still led to a meaningful result. However, with improved data sharing within domestic government agencies, the GIS output could be optimized.* |
| United Arab Emirates | It is apparent that at least the Environment Agency of Abu Dhabi has a GIS database, which it is willing to make available for aquaculture zoning studies (see Table A8.2a).* |

* Status inferred from information in addition to survey responses.

## Section 4. Capacity building for spatial planning and management

### Summary of results

It is recognized that throughout the RECOFI area there will be a wide range of "players" or stakeholders that need to be involved in managing MSP. Many of these higher-level participants may have little awareness of, or background in, the importance of such planning or the varied technical solutions that can be best adopted. Thus, capacity building is needed here and in associated factors concerning the practical capability of operating and managing GIS. The need for additional awareness of spatially based management was noted in Bahrain, Iran (Islamic Republic of), Iraq, Qatar and Saudi Arabia, and all except Saudi Arabia noted a need for additional capacity building in the practical use of GIS. Only Qatar is able to offer capacity building in both the awareness of the importance of spatial planning and in practical GIS training, although Oman could contribute to the latter. For each RECOFI country, comments regarding capacity building for spatial planning and management were invited. These comments are extremely varied and need to be perused individually. However, with respect to initiating capacity building programmes it appears that only Qatar and to a lesser extent Oman would be in a position to deliver these; but before embarking on the delivery of these programme elements, the situation needs to be carefully reviewed.

### Analysis

Element 5, as explained in detail in FAO (2011),[1] is concerned with the vital need to promote awareness to non-GIS specialists of the value of spatially based analyses in addressing and resolving problems associated with geographically extensive activities. So it is already understood that diverse use, poorly planned use and changing natural conditions of the RECOFI marine waters has led to significant degradations in aquatic ecosystems, plus greatly reduced fish catches, and thus a perceived (and real) need that these problems must be urgently addressed. In an intensively used marine area such as the Gulf, one that comes under the jurisdiction of eight sovereign States, this can only be achieved through inter-regional cooperation, and this cooperation will involve a wide range of "players", many of whom will have little recognition of the value of spatial analyses. Hence, the task of Element 5 is to make certain that these "players" have the necessary background in what spatially based analyses are and what they can achieve. However, capacity building may also be needed in terms of the ability to carry out the spatially based analyses (Element 6). This effectively means that a range of trained personnel are available who are able to efficiently use the required hardware, software and data, plus the peripheral associated technologies that collectively form the basis of GIS.

The need for capacity building, and the ability to provide this, is shown in Table A8.4a. The need for additional awareness raising (Element 5) of spatially based analyses among managers (and other stakeholders) is noted for five RECOFI member countries, i.e. Bahrain, Iran (Islamic Republic of), Iraq, Qatar and Saudi Arabia. It might be assumed that this identified need is the general situation in many RECOFI countries, but it is one that might vary quite significantly between people and institutions within the relevant sectors or organizations within these countries. Nevertheless, it is important that a need has been identified, just as it is important that all managers and other influential personnel are well versed in GIS and related capabilities. In reality, it would be rather surprising if this type of capacity building were not needed in all RECOFI member countries, especially given the fact that, to be successful, marine spatial planning and management will need to incorporate matters relating to a wide range of marine-based activities plus the relevant marine biophysical influences.

Table A8.4a shows that capacity building in terms of hands-on training is even more in demand, with most RECOFI member countries recognizing this need. It might be surmised that, in some of the

[1] FAO/Regional Commission for Fisheries. 2011. *Report of the Regional Technical Workshop on Spatial Planning for Marine Capture Fisheries and Aquaculture. Doha, the State of Qatar, 24–28 October 2010.* FAO Fisheries and Aquaculture Report No. 961. Rome. 118 pp. (also available at www.fao.org/docrep/014/i2054e/i2054e00.pdf).

countries, significant GIS capacity in terms of trained operatives would exist, but these would be working largely in terrestrial-based spheres requiring spatial analyses. The move towards marine-based GIS is somewhat recent, certainly in areas where pressures and challenges have only recently been widely recognized. Table A8.4a itself cannot indicate the precise extent of the training needs, and these are likely to be highly variable among countries where the extent of marine activities themselves is similarly variable.

With respect to the ability to provide capacity building, this significantly reflects the extent of the needs, i.e. with most of those countries needing capacity building for spatially based management being unable to contribute to this. As can be seen, provision here is extremely minimal with only Qatar having the capacity to provide for both the building up of awareness raising in GIS and for practical GIS training, and Oman having some capacity to offer hands on training in GIS. However, as these two countries indicated a need for both forms of capacity building, then it is surprising that they have the capacities to offer additional support in either sphere. It is likely that in both cases there is spare capacity at specific GIS centres or in specific aspects of GIS awareness or training.

RECOFI countries were invited to provide specific comments on their needs for awareness building or practical GIS-based training, or on their ability to provide for these (see Table A8.4b). It can be seen that the comments reflect a wide disparity in perceived needs or provision between countries. Bahrain and Kuwait offered no comments and, based on answers to other sections of the questionnaire, it is reasonable to assume that with respect to the use of GIS or spatial planning in the marine field, very little work has been undertaken and, thus, all capacity building may be starting almost from scratch.

However, in the case of Bahrain, past activities have been undertaken in the field of GIS applications to marine and coastal areas (Geomatec, 2006[2]), that other private-sector work is still ongoing (see http://websrv.municipality.gov.bh/mun/docs/MunicipalConference2012/Day2_26thApril/papers/34.%20Michael%20Arrora.pdf), and that substantial marine-based data are available (see http://unesdoc.unesco.org/images/0013/001356/135689e.pdf). It is likely that specific project recommendations for establishing GIS for marine work in Bahrain may not have been carried out. Iraq too would commence any marine spatial planning activities from a very basic position, and any GIS-based work may take some time to organize and to materialize.

As Bahrain, it seems that the United Arab Emirates has also embarked on preliminary coastal studies focusing on aquaculture zoning along part of its coastline (Table A8.2a), but at present there is little knowledge on its capacity to undertake this work. Comments from Saudi Arabia are rather brief and thus uninformative. From replies given to the questionnaire in FAO (2011), it is clear that in Iran (Islamic Republic of) there are problems among middle management in respect to the benefits that GIS can provide. So, in six of the eight RECOFI countries, GIS capacity in terms of both awareness and the practical capability of undertaking marine spatial planning activities is at a very basic level and there would be a need to address this by future RECOFI spatial planning work.

Of the two countries where marine GIS capabilities appear to be most advanced (Qatar and Oman), it would seem that Qatar may possibly be best placed to carry out practical GIS training. As it reports (Table A8.4b), the Centre for GIS in the Ministry for Municipality and Urban Planning appears to be well set up, an observation noted by FAO staff during the Doha workshop of 2010, and could be well placed to carry out practical GIS training. To what extent this practical training could be carried out cost effectively on perhaps a fairly wide basis would need to be investigated, as would the ease of tailoring any courses to suit varied and possibly complex marine requirements. Oman also shows interest in offering GIS training, possibly via facilities at the Sultan Qaboos University, or through the ESRI GIS software house. The latter company's courses tend to be both expensive and intensive and as such they might not be best suited to the type of wide ranging GIS capability that is best procured

[2] Geomatec. 2006. *Marine Environmental Geographic Information System (MARGISII): Final Report.* Manama, Bahrain, Geomatec, Bahrain Center for Studies and Research. 72 pp.

for work in perhaps a government fisheries department, i.e. ESRI courses are more suited to requirements from private enterprises. Nevertheless, this GIS training source could well be investigated.

**Table A8.4a**
Capacity building for spatial planning and management

| Country | Need capacity building? | | Can provide capacity building? | |
|---|---|---|---|---|
| | On awareness raising to management | Hands-on training on GIS | On awareness raising to management | Hands-on training on GIS |
| Bahrain | X | X | | |
| Iran (Islamic Republic of) | X | X | | |
| Iraq | X | X | | |
| Kuwait | | X | | |
| Oman (for aquaculture) | | X | | X |
| Oman (for capture fisheries) | | X | | |
| Qatar | X | X | X | X |
| Saudi Arabia | X | | | |
| United Arab Emirates | NA | NA | NA | NA |

**Table A8.4b**
Capacity building for spatial planning and management (comments)

| Country | Comments |
|---|---|
| Bahrain | N/A. |
| Iran (Islamic Republic of) | The limited awareness at mid-senior level management of the benefits that GIS can provide along with potential restrictions on the distribution of software were recognized as constraints during the Doha 2010 workshop.* |
| Iraq | Iraq cannot provide capacity building. Iraq would be a willing recipient of capacity building training. In that case, a possible situation for hands-on GIS training would be for a group of 5–7 persons from the MoA/General Board for Fish Resources to attend training for 7–10 days.<br>• These persons do not have GIS skills, but they do have simple, basic information.<br>• The course could be taken at any nearby country having good training expertise.<br>• We need to know the most applicable software system for us.<br>• We do not have any available spatial data for Iraq that could be used for a course. |
| Kuwait | N/A |
| Oman (in respect to aquaculture) | The Ministry of Agriculture and Fisheries Wealth does not provide/ have any courses on Remote Sensing and GIS.<br>However, we are hoping to collaborate with parties that do provide courses on the same such as Sultan Qaboos University and the German University of Technology. Last year, contacts were initiated with Cornell University in the US and we are planning to collaborate with them in terms of Remote Sensing and GIS development in our organization. We will start this by conducting a small workshop after we get approvals from our higher management team. (Details: Introduction to Remote Sensing and GIS (course - Sultan Qaboos University), Andy Yaw Kwarteng, PhD, Director, Remote Sensing and GIS Center, Sultan Qaboos University.<br><br>In addition, we are in contact with a company that works in the field of GIS in Oman and they will provide us with the software and training, and will provide consultancy when needed. More information about the company can be found at: Esri Muscat, www.esrimuscat.com<br><br>The course can be attended by the person responsible for RS and GIS and other staff in the environmental section of the aquaculture centre. Courses will be at different levels and stages, starting from beginner to advanced. Normally the course is intensive with different materials. ESRI is the company that provides the GIS software; we will also use ENVI software. The company will give support in the use of this system. |
| Qatar | The Centre for GIS, Ministry for Municipality and Urban Planning, is an authorized body to conduct and impart GIS training in the country. The courses may be customized according to user needs. The Centre offers ESRI notified courses and training with the trainers coming from ESRI. |
| Saudi Arabia | Request basic GIS training on Fisheries. |
| United Arab Emirates | In the project referred to in Table A8.2a, a key element of the work was to closely engage Environment Agency Abu Dhabi staff and ensure capacity building at every stage of the project. This could be an effective way to enable internal capacity building.* |

* Status inferred from information in addition to survey responses.

## Section 5. GIS Implementation strategy

**Summary of results**

Answers to the questions in this section should give good guidance as to the existing GIS capacity plus how the country might best contribute (or not) to a regional marine spatial strategy. However, the answers received were generally not well directed towards the questions asked, and useful information was only obtained from half of the countries. For Iraq and Kuwait, it was ascertained that they were not yet in a position to discuss in any detail how GIS might best be organized and at which locations it might function. For capture fisheries in Oman, some GIS implementation aims were planned and might be initiated. Only in the case of Qatar were there stronger indications that GIS for marine purposes had undergone some considerable planning, and that these plans had a strong potential to be implemented.

**Analysis**

This section of the questionnaire seeks to establish how GIS capability might best be organized in each of the RECOFI countries. Answers to this question should provide considerable clues as to whether individual countries consider that they have the capability to implement GIS as a functioning marine spatial planning tool, and possibly how they could best aid other countries to enhance their GIS capabilities. Answers (shown in Table A8.5) may also assist in the rationalization of GIS operations – this is likely to be advantageous when working in an inter-regional capacity.

However, most RECOFI country answers provided in response to the questions in this section did not properly address the issues requested. For example, as of 15 October, no comments had been received from the United Arab Emirates, and the comments from Saudi Arabia suggest that this matter has yet to receive detailed investigation. Comments from Iran (Islamic Republic of) indicate that further analyses are required because there are only indications that GIS capability is more advanced in Hormozgan Province (although from a marine fisheries, and indeed a mariculture, perspective this location might be preferential, i.e. as the province has an extensive coastline on RECOFI waters). The comments from Bahrain are not useful in this analysis as they only generally note the potential usefulness of GIS in that country's marine situation, i.e. with there being very limited marine waters to manage.

Two of the remaining RECOFI countries are in a similar situation with regard to GIS implementation for fisheries. Both Iraq and Kuwait have no functioning marine GIS capacity, and they recognize that they would require virtually all the basic GIS implementation requirements in terms of hardware, software, data collection and storage methods, plus GIS training, knowledge of the functionality of the systems and the uses to which it could be put. For Iraq, any GIS-based operation is likely to be rather low-key, i.e. due to extremely small territorial water area, but as this area is heavily used by shipping, it will be vital that marine spatial planning is activated in conjunction with its neighbours.

Iraq further indicates that it is likely to be totally dependent on outside aid to obtain any kind of spatially based management programme activated. For Kuwait, which has a much larger marine territorial waters area, there appears to be more potential to procure access to local GIS functionality through one or both of the Public Authority of Agricultural Affairs and Fish Resources and the Kuwait Institute of Scientific Research. This potential needs to be further explored.

According to Table A8.5, the two remaining RECOFI countries have more marine GIS potential than the other countries. Oman has divided its answers to all questionnaire sections into those based on either aquaculture or on marine fisheries. With respect to aquaculture, the comments simply provide a listing of the types of GIS-related tasks and activities that might be pursued in order to enhance GIS-based activities. In fact, these could relate to either fisheries or aquaculture. Thus, there are few clues as to "how the GIS could be actually organized in your country and in which location(s)". The comments dealing with capture fisheries for Oman give a few useful details, with the suggestion that the Ministry of (presumably) Agriculture and Fisheries Wealth has a small GIS operation that could be expanded so as to house Spatial Data, GIS Analyses and Information Management and Community Network sections. It appears that Qatar is furthest advanced in its capacity to utilize GIS for spatial

planning and management, i.e. as the country has been using GIS for nearly two decades. There are wide data and working interconnections between government departments, private companies and academic institutes, and the Ministry of the Environment has an extensive database covering fisheries related topics. Much GIS work has already been undertaken in the marine and coastal zones. Adoption of GIS specifically for MSP and for fisheries and aquaculture projects would be a new experience for Qatar, but it is a venture that it is willing to adopt. Table A8.5 suggests some of the main lines of new working practices that might be adopted. It is not clear which ministry would take on this MSP planning and fisheries/aquaculture role, but being a small country this should be easy to decide.

**Table A8.5**
GIS implementation strategy

| Country | Please suggest how the GIS could actually be organized in your country and in which location(s) |
|---|---|
| Bahrain | Bahrain officially implemented the Bahrain Spatial Data Infrastructure Portal (BSDI) in 2005. Since this date, the Portal has contained the countries terrestrial data. A marine GIS data project for offshore data was initiated and completed in 2006. This MarGIS project comprised the collection and recording of most fundamental marine data sets and was recently (2011) linked to the BSDI portal for sharing amongst related stakeholders.<br><br>To sum up, the implementation of a GIS application for marine spatial planning, for fisheries, and for aquaculture projects is considered a new and strategic venture for Bahrain to support the Kingdom's 2030 vision, and to help to preserve, protect, analyze and plan for decision-making of the marine habitat and fisheries. |
| Iran (Islamic Republic of) | We have not initiated a GIS for marine spatial planning yet but Hormozgan Province is much better than other provinces to start with. |
| Iraq | Iraq does not have any strategy or programmes or activity on the implementation of GIS in spatial planning for marine capture fisheries and aquaculture. Accordingly, Iraq suggests that they need a training programme from outside experts or training courses from developed countries who have experience in these activities. GIS could be organized for Iraq by:<br>• conducting a workshop to raise awareness on GIS applications for decision-makers;<br>• conducting a second workshop on GIS training for about 10-15 people and aimed at technical personnel. |
| Kuwait | Kuwait does not have any programme for GIS-based spatial planning at the present time. However, it is suggested that GIS-based spatial planning activities for Kuwait fisheries development could be organized at the premises of PAAF (Public Authority of Agriculture Affairs and Fish Resources) with the vital involvement of KISR (Kuwait Institute of Scientific Research). |
| Oman (for aquaculture) | A GIS for spatial planning in Oman could be organized as follows:<br>• Identify, catalogue and inventory the available physical, biological, and chemical data and reports for the marine environment.<br>• Document available infrastructures for human uses including, fishing ports/harbours, fisheries companies, ice factories, cold storages, surveillance and licenses etc.) at different administrative levels/boundaries within the Sultanate.<br>• Develop a detailed assessment of data gaps and a prioritized list of data collection requirements that are needed to fill fisheries data gaps.<br>• Archive fisheries resources information into a comprehensive GIS for a data management strategy to address all data gathering, storage, querying, data retrieval and mapping needs. |
| Oman (for capture fisheries) | Currently there is a small section that deals with GIS data in the Ministry. However, there is an ongoing effort to establish a GIS department with a:<br>• spatial data section;<br>• GIS analyses section;<br>• information management community network section.<br>It is important that all staff have a strong knowledge of fisheries and marine sciences in addition to having strong backgrounds in information communication technology. |
| Qatar | GIS as a technology has been in implemented in Qatar since 1995. Many Government agencies, corporate bodies, and academic institutes in the country are now connected to the GISNet and share data. The Ministry of Environment has a rich environmental database catering to environment, fisheries and agriculture. Although the majority of the GIS data covers the terrestrial domain, recently there has been a lot of work done in coastal and marine zones.<br><br>Spatial planning for marine capture fisheries and aquaculture is a new facet for the GIS in Qatar. Although GIS is being used in the country at an advanced level, its adoption in fisheries is very subject-specific and |

| Country | Please suggest how the GIS could actually be organized in your country and in which location(s) |
|---|---|
| | new. The staff working in marine capture fisheries and aquaculture need to be appropriately oriented on the use of GIS in this field, especially in coordination with GIS personnel from the Ministry. A suitable organization could be to form a task force with personnel from both GIS and fisheries. This task force could define a training curriculum combining aspects of both GIS and fisheries with relevance to spatial planning. The use of case-studies would be beneficial. A step-wise approach for this could be:<br><br>1. Build a team drawn from fisheries and GIS and departments under the guidance of RECOFI.<br>2. Identify the building blocks (various data sets) to build the foundation for marine spatial planning.<br>3. Assess the availability and the dissemination of data.<br>4. Identify gaps.<br>5. Define mechanisms for filling the gaps.<br>6. Involve other departments that are related to research and studies related helpful to fisheries.<br>7. Start putting together the marine spatial plan.<br>All these to be undertaken under the guidance of RECOFI. |
| Saudi Arabia | Locations where GIS infrastructure and personnel could be located include: Jeddah, Dammam, Jazan, Tabuk. Suggestions for how a GIS could be organized are not completely ready as of now. |
| United Arab Emirates | No response. |

**Annex 1**

## Questionnaire survey form

## RECOFI Spatial Planning Development Programme for Marine Capture Fisheries and Aquaculture Survey

**Purpose:** The purpose of this survey is to determine the status of implementation of the Regional strategy for spatial planning developed for RECOFI in 2010 and to obtain information on national capacities and on the agencies mandated to implement fisheries and aquaculture management projects, with particular emphasis on data availability and spatial tools for planning and analysis in each of the eight RECOFI member countries. The results of this survey will be used to prepare a proposal and an initial action plan for a development programme. The details of this programme will be finalized at a regional brainstorming workshop.

**Participation:** Eight RECOFI member countries (the Kingdom of Bahrain, the Islamic Republic of Iran, the Republic of Iraq, the State of Kuwait, the Sultanate of Oman, the State of Qatar, the Kingdom of Saudi Arabia and the United Arab Emirates) will be invited to participate in the survey.

**Questionnaire survey:** The questionnaire survey, jointly developed by FAO staff, two international consultants, and one National consultant on GIS from the Sultanate of Oman will be distributed at the beginning of July 2012. The completed questionnaires are expected **no later than 31 July 2012**.

**Responsibility for completing the questionnaires:** Through the RECOFI Working Group on Fisheries Management (WGFM) and the Working Group on Aquaculture (WGA) National Focal and Alternate Points, this survey should be completed by the national competent authority or other senior government officer(s) with primary responsibility for national fisheries and aquaculture issues, with the assistance of national fisheries and aquaculture experts, and in close consultation with a national consultant on GIS (focal point) and GIS personnel from each country.

**Product:** FAO will analyze the survey returns to prepare a draft programme to be distributed via email a few weeks prior to the workshop and then presented at the regional workshop on spatial planning at the FAO Regional Office for the Near East, Egypt, Cairo, from 25–27 November 2012. Participants from member countries will have the opportunity to present and discuss the responses given to the draft programme. Discussions at the workshop will aim to complete the regional spatial planning development programme.

### Details of person(s) completing the survey questionnaire

**COUNTRY:**

| | | | |
|---|---|---|---|
| **Name:** | | | |
| **Title:** | | | |
| **Status or position:** | | | |
| **Institution:** | | | |
| **Mailing address:** | | | |
| **Telephone:** | | | |
| **Facsimile:** | | | |
| **E-mail:** | | | |
| **Signature of completing official:** | | | |
| **Date:** | | | |

Note: More than one person may be responsible for completing the survey questionnaire.

## INTRODUCTION

This survey is a follow-on activity to the Regional Technical Workshop on Spatial Planning for Marine Capture Fisheries and Aquaculture which took place in Doha, Qatar (24–28 October 2010).[1]

The workshop report outlines a regional strategy for the spatially based planning and management of marine capture fishery activities and mariculture in the RECOFI region. At the Sixth session of RECOFI in Rome, in May 2011, the Commission agreed to adopt an FAO/RECOFI joint WGA and WGFM regional spatial planning approach to marine capture fisheries and aquaculture for the Gulf area and, within available resources, to provide the necessary support for follow-up action for the strategy's implementation.

The regional strategy endorsed by the Commission sets our series of programme components, elements and activities. The aim of this survey is to address some of the key elements of the strategy in order to develop a "Development Programme" for the development of the capacity to use spatial tools in fisheries and aquaculture management and planning. The information gained from the survey will allow the workshop organizers to gain insight on the current situation in each RECOFI member country with respect to GIS needs and capacity.

## SECTION 1. Status of implementation of Elements of Regional programme

Please indicate which **Elements** of the proposal for a Regional Programme for Implementing a Strategy on Spatial Planning for Marine Capture Fisheries and Aquaculture in RECOFI Member have been implemented, initiated and/or discussed within your countries or in a regional context. Please tick one or more boxes:

| | **Implemented** | **Initiated** | **Discussed** |
|---|---|---|---|
| Element 1. Regional Policy and Marine Spatial Planning | ☐ | ☐ | ☐ |
| Element 2. National needs and national GIS/RS related capacities | ☐ | ☐ | ☐ |
| Element 3. Legislation and regulation | ☐ | ☐ | ☐ |
| Element 4. Regional and national cooperation and networking | ☐ | ☐ | ☐ |
| Element 5. Awareness building and promotion of spatial planning to non-GIS specialists | ☐ | ☐ | ☐ |
| Element 6. Regional or national basic training in GIS | ☐ | ☐ | ☐ |
| Element 7. GIS project management | ☐ | ☐ | ☐ |
| Element 8. Identifying GIS-based Pilot Projects and their data needs | | | |
| Element 9. Continuing data collection and storage | ☐ | ☐ | ☐ |
| Element 10. Integration of GIS related information and publications databases | ☐ | ☐ | ☐ |
| Element 11. System's requirements, design, procurement and testing | ☐ | ☐ | ☐ |
| Element 12. Continuity of the GIS capacity within the Strategy | ☐ | ☐ | ☐ |

[1] See: FAO/Regional Commission for Fisheries. 2011. *Report of the Regional Technical Workshop on Spatial Planning for Marine Capture Fisheries and Aquaculture. Doha, the State of Qatar, 24–28 October 2010*. FAO Fisheries and Aquaculture Report. No. 961. Rome. 118 pp. (also available at www.fao.org/docrep/014/i2054e/i2054e00.pdf).

## SECTION 2. Identification of GIS-based pilot projects and their data needs

2.1 **Element 8 of the proposed Regional Programme** attempts to identify GIS-based project that can be readily supported, replicated or planned. Has your country already identified such projects related to either marine capture fisheries and/or to aquaculture? If yes, can you provide a short description? Please tick one box:

☐ No projects ☐ Yes, please provide title of project (include name and email of contact person):

_____
_____
_____
_____
_____
_____
_____

2.2 If it is a **marine capture fisheries** project, please identify the issue/theme that the project(s) is going to address. Please tick one or more boxes:

| |
|---|
| ☐ **Distribution displays** – this is simply drawing of cartographic visualizations (maps) to show the distribution of any feature or combination of marine or fisheries features. |
| ☐ **Marine habitat mapping and analyses –** establishing the essential components of fish habitats is an ideal way to utilize GIS, e.g. perhaps with a view to aquatic conservation designations. |
| ☐ **Modelling** – these functions include work on illustrating themes, often in a simplistic or general way, or there may be predictive modelling to show the outcome of potential decisions or actions. |
| ☐ **Monitoring management or enforcement policies** – e.g. optimizing the disposition of fishing effort, perhaps via the help of electronic log-book or VMS-based tracking data. |
| ☐ **Ecosystems relationships –** e.g. predator/prey relationships or relationships between fish distributions and any environmental parameter. |
| ☐ **Stock enhancement** – e.g. the timing and selection of sites for artificial stocking. |
| ☐ **Marine zoning and reserve allocation –** i.e. both general zoning of the marine area, and identifying suitable areas for species protection including analyzing the results achieved through protection. |
| ☐ **The creation of economic surfaces –** i.e. allowing researchers to model the likely income derived from fishery products based on alternative management and resource extraction scenarios. |
| ☐ **Fishing fleet disposition and behaviour –** i.e. to best sustain fish yields, vessels need to be optimally deployed throughout a management or ecosystem's area. |
| ☐ **Ecosystems approaches to management** – GIS is the ideal tool to assist in identifying ecosystems dis-equilibrium, and to predict and depict scenarios for improved management scenarios across the wider social, economic and environment considerations. |

| |
|---|
| ☐ **Other (please specify):** |

1.3 If it is an **aquaculture** project, please identify the issue/theme that the project(s) is going to address. Please tick one or more boxes:

| |
|---|
| ☐ **Training and promotion of GIS –** Example applications in the formal and gray literature provide the breadth of accumulated practical experience in applying GIS and remote sensing to aquaculture that can be used for self-training, training courses and for promotion. Compiled examples can be found at FAO's GISFish Web site. (www.fao.org/fishery/gisfish/id/1134). |
| ☐ **Development of aquaculture –** Among the main tasks for GIS are estimating aquaculture potential, assessing the suitability of sites and carrying out zoning, strategic planning for development, anticipating the consequences of aquaculture (environmental, social and economic impacts). |
| ☐ **Aquaculture practice and management –** There are a number of uses for GIS here including **i**nventory and monitoring of aquaculture and the environment, assessing environmental impacts of aquaculture, restoration of aquaculture habitat and web-based aquaculture spatial information systems that support real time management using remote sensing and GIS or aid in regulation and administrative management. |
| ☐ **Multi-sectoral development and management that includes aquaculture –** Two specific kinds of applications are the management of aquaculture together with fisheries and planning for aquaculture among other uses of land and water; however, GIS applied to marine spatial planning in general also could be included |
| ☐ **Other (please specify):**<br><br>*Note:* Perhaps an area being developed or of interest could be "**mapping**" related to **aquatic animal health** as a follow-up to a few activities of this RECOFI workshop: FAO FAO/Regional Commission for Fisheries.2009. Report of the regional technical workshop on aquatic animal health. Jeddah, Kingdom of Saudi Arabia, 6–10 April 2008. FAO Fisheries and Aquaculture Report. No. 876. Rome, FAO. 119 pp. (www.fao.org/docrep/014/i0572e/i0572e00.htm). |

1.4 If you have an ongoing project and/or a project that is being planned please complete the **two-page** concept note describing the contents listed below, i.e. an example is enclosed separately that you can use as a guide.

Contents of project concept note template:

- Title of project
- Rational and background:
- Data needs:
- Tools/models:
- Project expected outcome:
- Project activities foreseen:
- Expected outputs:
- Project estimated draft budget:
- Project estimated time frame:
- Originators of project proposal:

## SECTION 3. Continuing data collection and storage

3.1 With regard to **Element 9** of the proposed Regional Programme on "Continuing data collection and storage" are spatial data and information being collected in your respective fisheries and aquaculture departments of your country?. Please tick one box:

☐ None ☐ Yes, please list the types of data being collected. For example, environmental (e.g. water, soils), physical (roads, cities, etc), socioeconomic (population density, markets, etc.) and provide name and email of contact person who manages and/or collects spatial data:

_____
_____
_____
_____
_____
_____
_____
_____

3.2 With regards to **Activities 20 and 21** of **Element 9**:

a) Are there any post-collection activities for updating and editing data conducted in your country? Please tick one box:

☐ None ☐ If Yes, please briefly describe:

_____
_____
_____
_____

b) Have database management systems been created in your country for the storage, security and management of all data needed for GIS projects? Please tick one box:

☐ None ☐ If Yes, please briefly describe:

_____
_____
_____
_____

c) Can the spatial data compiled and/or created in your country be easily shared? Please describe data sharing mechanisms:

_____
_____
_____
_____

## SECTION 4. Capacity building for spatial planning and management

4.1 **Elements 5 on "**Awareness building and promotion of spatial planning to non-GIS specialists" **and Element 6 on "**Regional or national basic training in GIS" aim to provide capacity building for spatial planning and management. To this end, does your country need capacity building or it is able to assist in providing capacity to other RECOFI member countries? Please tick one or more boxes:

a) Need capacity building.
☐ on awareness raising to management and/or ☐ hands-on training on GIS

b) Can provide capacity building.
☐ on awareness raising to management, and/or ☐ hands-on training on GIS.

Please describe below (i) the types of training available and (ii) name and email of contact person that can provide such training:

_____
_____
_____
_____
_____
_____

## SECTION 5. GIS Implementation strategy

5.1 **Activity 25** of the Regional Programme for Implementing a Strategy on Spatial Planning for Marine Capture Fisheries and Aquaculture consists of a 'National GIS Committees' to discuss with fisheries/aquaculture authorities the location(s) for GIS activity to be based, plus the activities to be performed at each location". To this end, since Activity 25 is strongly related to the overall goal of developing the capacity to use spatial tools in fisheries and aquaculture planning could you please suggest how the GIS could be actually organized in your country and in which location(s):

_____
_____
_____
_____
_____
_____
_____
_____
_____
_____
_____

**Annex 2**

**List of persons completing the questionnaire survey**

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**APPENDIX 9**

# Proposal for a Spatial Planning Development Programme for Marine Capture Fisheries and Aquaculture in RECOFI member countries

prepared by
RECOFI Regional Technical Workshop on Spatial Planning
Development Programme for Marine Capture Fisheries and Aquaculture

Cairo, the Arab Republic of Egypt
25–27 November 2012

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**CONTENTS**



## SUMMARY

This spatial planning programme is a follow-on activity to the Regional Technical Workshop on Spatial Planning for Marine Capture Fisheries and Aquaculture, which took place in Doha, Qatar (24–28 October 2010).

This document outlines a regional programme to allow for the spatially based planning and management of marine capture fishery activities and mariculture in the RECOFI region. The programme will be presented to the Commission for its consideration during the RECOFI meeting scheduled for May 2013.

The workshop report from Qatar[1] outlines a regional strategy for the spatially based planning and management of marine capture fishery activities and mariculture in the RECOFI region. At the sixth

[1] FAO/Regional Commission for Fisheries. 2011. *Report of the Regional Technical Workshop on Spatial Planning for Marine Capture Fisheries and Aquaculture. Doha, the State of Qatar, 24–28 October 2010*. FAO Fisheries and Aquaculture Report No. 961. Rome. 118 pp. (also available at www.fao.org/docrep/014/i2054e/i2054e00.pdf).

session of RECOFI in Rome, in May 2011, the Commission agreed to adopt an FAO/RECOFI joint WGA and WGFM regional spatial planning approach to marine capture fisheries and aquaculture for the Gulf area and, within available resources, to provide the necessary support for follow-up action for the strategy's implementation.

The regional strategy endorsed by the Commission sets out 4 programme components, 12 elements and 30 activities (see Box 1 for programme components and elements). The purpose of this programme is to address some of the key elements of the strategy in order to develop a "detailed spatial planning development programme" for the development of the capacity to use spatial tools in fisheries and aquaculture management and planning. The information gained from the questionnaire survey conducted in 2012 allowed the workshop organizers to gain insight on the current situation in each RECOFI member country with respect to GIS needs and capacity.

**BOX 1**
**Programme components and elements contributing to the complete RECOFI spatial planning process**

**Programme component 1: Contribution to improved marine governance through marine spatial planning**
Element 1: Regional policy and marine spatial planning
Element 2: National needs and national GIS and remote-sensing-related capacities
Element 3: Legislation and regulation
Element 4: Regional and national cooperation and networking
**Programme component 2: Capacity building for spatial planning and management**
Element 5: Awareness building and promotion of spatial planning to non-GIS specialists
Element 6: Regional or national basic training in GIS
**Programme component 3: Spatial planning projects and their data needs**
Element 7: GIS project management
Element 8: Identifying GIS-based pilot projects and their data needs
Element 9: Continuing data collection and storage
Element 10: Integration of GIS-related information and publications databases
**Programme component 4: GIS implementation strategy**
Element 11: System requirements, design, procurement and testing
Element 12: Continuity of GIS capacity within the strategy

**Implementation of the Development Programme**

The key elements of the proposed Development Programme are based on: (i) the Regional Programme for Implementing a Strategy on Spatial Planning for Marine Capture Fisheries and Aquaculture in RECOFI member countries; and (ii) the feedback received through a questionnaire survey conducted in 2012. The Development Programme is essentially based on 4 of the programme components and 8 of the 12 elements (as shown in Box 2).

**BOX 2**
**Programme components and elements contributing to the present RECOFI Spatial Planning Development Programme**

**Programme component 1: Contribution to improved marine governance through marine spatial planning**
Element 2: National needs and national GIS / remote sensing related capacities
**Programme component 2: Capacity building for spatial planning and management**
Element 5: Awareness building and promotion of spatial planning to non-GIS specialists
Element 6: Regional or national basic training in GIS
**Programme component 3: Spatial planning projects and their data needs**
Element 7: GIS project management
Element 8: Identifying GIS-based pilot projects and their data needs
Element 9: Continuing data collection and storage
Element 10: Integration of GIS-related information and publications databases
**Programme component 4: GIS implementation strategy**
Element 11: System requirements, design, procurement and testing

## BACKGROUND

The fifth session of RECOFI (Dubai, the United Arab Emirates, 12–14 May 2009) recommended that a joint workshop should be undertaken between the Working Group on Fisheries Management (WGFM) and the Working Group on Aquaculture (WGA) concerning the use of spatial planning tools, i.e. GIS, remote sensing and mapping for marine capture fisheries and "aquaculture". The main focus of the workshop was to conduct an assessment of how the use of spatial planning tools in the region might meet the needs of both marine capture fisheries and mariculture. The need to seek improvements in management practices arises from the fact that production of fishery products from marine areas in the RECOFI region has been falling rapidly in the last decade. The following, mostly human-induced factors, are the likely cause of this:

- Fishing effort exceeds optimum levels for most species.
- There are large bycatch losses of finfish associated with the dominant shrimp fisheries.
- Fisheries regulations are weak, and are not rigorously enforced.
- There are insufficient data upon which to carry out adequate fisheries management.
- There is extensive pollution from hydrocarbon activities.
- Other sources of pollution come from sewage effluents, chemical and fertilizer plants, hypersaline waters from desalination plants and ballast discharges from ships.
- High-quality coastal habitats have often been degraded or ruined by coastal dredging and high-density urban developments that receive little regulation.
- There is a long-term growth in harmful algal blooms and de-oxygenated waters.

As well as summarizing these problems, Sale *et al*. (2011; p. 4) noted "The Gulf's geography, climate, and pattern of use put it at risk for various types of environmental degradation, and the current capacity for environmental management is inadequate." All of these negative trends need to be reversed.

With respect to aquaculture (mariculture), this is a food production subsector receiving considerable attention for its ability to assist in filling the growing fish-supply gap. At present, aquaculture is little practised in most RECOFI countries, and it is likely that current annual average mariculture production from all eight RECOFI country areas covered by this strategy would not exceed a few thousand tonnes. In terms of length of coastline, area of exclusive economic zones (EEZs) and, in the larger RECOFI countries, areas where there appears to be little competition for inshore or coastal

waters, it is likely that the Gulf has the potential for the production of much greater quantities of farm-reared marine fish, plus a wider range of species. However, aquaculture cannot be practised everywhere; in order to flourish, it requires a unique set of natural resources, as well as favourable social and economic conditions. The use of appropriate spatial tools would allow the identification and possible allocation of specific geographical areas for aquaculture practices.

The characteristics of marine capture fisheries are highly variable from one RECOFI country to another. The larger countries have relatively thriving fisheries producing up to 300 000 tonnes per annum i.e. in Iran (Islamic Republic of), whereas the smaller countries such as Bahrain, Iraq, Kuwait and Qatar, have annual production figures of less than 20 000 tonnes. Marine fisheries are dominated by artisanal fishers, there are a wide variety of fishing methods used, shrimp fisheries now dominate production, there is much illegal fishing, and fisheries management is generally poor. Data and statistics on production are highly unreliable and many of the data is up to ten years out of date. Both Oman and Iran (Islamic Republic of) have plans to expand their production considerably, whereas, in contrast, Qatar has entirely closed its shrimp fishery.

Given the catalogue of disparate facts on mariculture and on marine capture fisheries, plus pronounced problems in respect to human-induced factors affecting the marine environment of the Gulf, it was relevant and timely that the Regional Technical Workshop on Spatial Planning for Marine Capture Fisheries and Aquaculture took place in Doha, Qatar (24–28 October 2010). Results of the workshop are reported in FAO/Regional Commission for Fisheries (2011). The main outcome of the workshop, to which all RECOFI States subscribed, was a regional programme allowing for spatially based planning and management of marine capture fishery activities and mariculture in the RECOFI region. This programme was considered a sound basis upon which to develop a detailed programme for the development of the capacity to use spatial tools in fisheries and aquaculture management and planning. At the sixth session of RECOFI in May 2011, the Commission agreed to adopt the FAO/RECOFI joint WGA and WGFM regional spatial planning approach to marine capture fisheries and aquaculture for the Gulf area. This technical workshop is the result of this agreement.

It should be mentioned that, as well as the pressures facing fisheries, mariculture and the marine environment of the Gulf, there are other background pressures that are fuelling the need for the adoption of spatially based planning and management systems in the RECOFI region. It has been widely reported that emerging issues affecting capture fisheries, aquaculture and marine environments are those of marine spatial planning (MSP)[2] and the environmental approach to fisheries (EAF) and to aquaculture (EAA)[3] (see Carocci *et al.*, 2009; Ehler and Douvere, 2009; Aguilar-Manjarrez, Kapetsky and Soto, 2010; FAO, 2010). While space precludes a discussion here on these initiatives, the reasons why they are important to this background discussion should be briefly stated. Marine spatial planning is the recognition that if areas of marine space are to be used successfully and sustainably, then they need to be managed in respect to all users of that space. As well as fisheries or mariculture, users of marine space may be other resource extractors (e.g. aggregates, oil, gas), energy generators (e.g. wind, wave, tidal), shipping and ferry networks, recreation anglers, yachting and holiday resorts, as well as a range of conservation or military-training areas. In marine areas such as the Gulf, where many jurisdictions may occur in a relatively small area, sustainability for all activities will mean that a high degree of cooperation is required between nation States. Thus, realistic spatial planning nowadays requires working in an environment of trust, cooperation and sharing.

[2] Marine spatial planning is concerned with the fact that if all marine activities are to be sustainable in the longer term, then the activities will have to be co-managed. This will largely involve cooperative working and various types of zoning for different marine activities.

[3] The EAF and EAA require that management considers the whole of the fisheries production and consumption environments as aspects needing to be managed.

The EAF and EAA also bring added demands to those imposed by traditional fisheries or aquaculture management methods. Management of the whole ecosystem implies that environmental, economic and social variables must also be considered when decisions are made, i.e. as all of these perspectives will again contribute to longer-term sustainability of the activity. This has considerable implications for spatially based management, largely in terms of data needs, stakeholder considerations and complexity of the functional analyses that may be performed.

A final background area of considerable importance concerns the potential needs of the various participants in spatial-based decision-making and their varied starting points with respect to spatial knowledge and to GIS. From reading the questionnaire survey responses gained from both the 2010 survey, carried out to inform the RECOFI regional technical workshop in Doha (24–28 October, 2010), and the questionnaire survey to inform the present regional technical workshop in Cairo (25 – 27 November, 2012), it is apparent that there is a wide disparity between the eight RECOFI countries in terms of their levels of experience and their needs with regard to spatial management systems.

This is not only an overall disparity but there are also wide differences depending on different aspects relating to the whole area of GIS, remote sensing and spatial management. The implications of these disparities are significant in terms of such as how workshop programmes are best organized, in the dissemination of information, in training needs, in resources available, in IT expertise and in the scale of GIS operations. Therefore, the activities that are taken forward in order to meet these variable demands have to be extremely varied, but at the same time they will have to ensure that final, universal goals are attained. Box 3 is included to illustrate the variability of comments given as questionnaire responses.

**BOX 3**

**Indications of the variability or constraints in respect to GIS knowledge and provision**

**Constraints to achieving spatial planning and management:**

- Lack of knowledge of GIS and/or remote sensing as a means to aid decision-making in capture fisheries or aquaculture.
- Lack of access or unavailability of data requirements.
- Insufficient expertise.
- Insufficient institutional capacity and governance (e.g. lacking clear definitions of responsibilities and roles within the institutional governing bodies).
- Incomplete legal frameworks (e.g. means for enforcement and control, overlapping jurisdictions).
- Lack of clear identification of issues relating to capture fisheries and aquaculture.
- Lack of clear understanding of interactions with other sectors.

**Needs relative to spatial data availability:**

- "Currently we do h**ave not access to any spatial data or persons** with spatial data skills"
- "The first priority is to update data for GIS"
- "the GIS centre is well equipped with infrastructure, data, and technical personnel"
- "this database suffered from a reluctance of government agencies to share spatial data"
- "The specific content of that database is unknown"
- "This is perhaps is the only country in the world having Nation-wide access to all GIS data"

**Constraints relative to GIS training or capacity needs:**

- "limited awareness at senior level management of the benefits that GIS can provide ... were recognized as constraints during the Doha 2010 workshop"
- "These persons do not have GIS skills, but they do have simple, basic information"
- "The Centre for GIS, Ministry for Municipality and Urban Planning, is an authorized body to conduct and impart GIS training"
- "We request basic GIS training on Fisheries"
- "Spatial planning capacities vary from country to country and these generally need to be enhanced"

## PURPOSE

At the fifth session of RECOFI in Dubai, the United Arab Emirates, in May 2009, it was identified that the RECOFI region could benefit from improved spatial management of its fishery and aquaculture activities. Resulting from this decision, the main purpose of this document is to present a draft strategy to enhance and accelerate spatial planning for marine capture fisheries and mariculture in the region, specifically with reference to development of the capacity to use spatial tools in fisheries and aquaculture management and planning. Although the general need for improved fisheries management in the RECOFI region has long been recognized, as has the fact that most management issues are spatially based, until a formal programme for implementing a strategy for spatial planning had been devised and accepted, then this form of improved fisheries and aquaculture management could not be adopted.

Such a programme was presented following the workshop in Doha, Qatar, in October 2010 (see FAO/Regional Commission for Fisheries, 2011; pp. 86–112). The strategy itself was the result of initial ideas developed by FAO experts and external consultants, ideas that have been developed and substantiated through workshop participation. The strategy also drew upon a questionnaire survey carried out among fisheries/aquaculture personnel from government departments in the eight RECOFI countries. The workshop outputs were bolstered by invited comments on the responses to the questionnaire, a review of the literature and by statistics on aquaculture and fish production in the region, as well as by Internet searches relevant to GIS and remote sensing related to regional marine

capture fisheries and mariculture. It was on the basis of this aggregated evidence, that the regional spatial strategy was developed. The regional programme for implementing the strategy on spatial planning for fisheries and aquaculture was discussed and then adopted following the sixth session of RECOFI in Rome, in May 2011. Box 1 shows the main "Programme Components" and "Elements" of the complete spatial planning adoption strategy. The "Elements" have been further broken down into a series of 30 individual "Activities". Detail on the content of each "Programme Component", "Element" and "Activity" is provided in FAO/Regional Commission for Fisheries (2011; pp. 95–106).

The purpose of the present workshop is to develop a detailed programme allowing for a range of the "Elements" and their "Activities" to best be activated; these are the Programme Components 1, 2, 3 and 4 as shown in Box 2. The contents of this box reveal that the unifying feature among most of the "Activities" is "GIS". Thus, the overall concern here is with the introduction of GIS among RECOFI members as a means of carrying out spatially based fisheries and mariculture management. This course of action is being followed because, in the last 30 years, GIS has proved to be unequalled as a digitally based spatial management tool for use in terrestrial applications, and in the past two decades it has been progressively and successfully introduced for marine fisheries and aquaculture use. The use of GIS will go a long way towards not only improving fishery production and the marine ecosystems in the RECOFI region, but it will also inspire a new way of working in which the spatial interlinkages between all functions controlling production are recognized as important ingredients in environmental and ecosystem sustainability. It is further recognized that multisectoral and inter-regional management, as in the case of the proposed regional strategy, needs to be part of an ecosystem-based management framework that inspires and instigates planning and decision-making processes at all levels, including socio-economic and institutional aspects.

The purpose of (and output from) the workshop is to discuss the following "Activities" that sequentially form subcomponents of the "Programme Components" shown in Box 2 (with Activity numbers being listed),[4] with a view to achieving an output consisting of a report showing how the Activities might best be achieved:

1. Establish national marine committees to oversee GIS-based spatial management project work at a national level (Activity 9).
2. Assess the capacity of higher-level decision-makers to appreciate the bases for, and demands of, spatially based problem solving analyses, and deliver a range of promotional materials where required (Activity 15).
3. Deliver general training and principles to middle-level decision-makers and managers on the use of GIS, remote sensing and other related tools (Activity 16).
4. Identify and appoint a high-quality candidate to be responsible for promoting and managing all GIS work at a national level (Activity 18).
5. At regional and national levels, identify and then prioritize, potential spatially based projects and pilot projects. The GIS committee (see bullet 1) to aid with this task (Activity 19).
6. Identify site locations in RECOFI countries where GIS can best be placed for fisheries and/or mariculture work, plus the remit for each location (Activity 25).
7. Decide upon the required GIS structure at each GIS working site identified in terms of personnel, hardware, software, systems architecture, etc. (Activity 26).
8. Implement the GIS and carry out GIS procurement and testing activities necessary to bring the system up to the needs requirement (Activity 27).
9. Identify sources of basic GIS training at national and regional scales and deliver training to GIS operatives as necessary (Activity 17).

[4] Here the "Activities" are simply described. The precise wording of each "Activity" can be found in Table 1 of FAO/Regional Commission for Fisheries (2011; pp. 109–112). The "Activity" numbers (in brackets) do not appear sequentially because the original implementation strategy, as set out in Table 1, is grouped in "Programme Component" order and, as various activities can be carried out simultaneously, these do not strictly adhere to the "Activity" order.

10. Depending on the GIS-based projects chosen (bullet 5 above), assess data needs, identify possible data sources, and collect and assemble data (Activity 20).
11. Verification (checking and editing) of any data assembled (Activity 21).
12. Establish a secure database management system for storage and management of all data (Activity 22).
13. Establish library archives of useful GIS-based hardcopy materials (Activity 23).
14. Establish digital archives for data and information sources materials (Activity 24).

Preliminary budget estimates for the enactment of these activities are provided in Appendix 7.

## VISION

The long-term vision of the Regional Strategy for Spatial Planning for Marine Capture Fisheries and Mariculture in the RECOFI region is: "To illustrate how spatial planning tools are one essential element to achieving sustainable clean, healthy, safe, productive and biologically diverse marine seas in the RECOFI region, and how they allow for mariculture and marine fishery production activities to be maximized whilst at the same time taking into account the other users of the marine space."

## GUIDING PRINCIPLES

For any task being undertaken, there are many ways of establishing guiding principles. Principles may vary from an extreme whereby jurisdictional frameworks are heeded or other very legalistic restrictions are followed, to simply following a set of rather random guidelines. With respect to the task here, it seems that a pragmatic approach is one that formulates general guidelines under the two relevant headings of "Working" and "Sustainability" guiding principles.

### Working principles

These basically refer to the manner in which a programme will be delivered, and these must be relative to the task at hand. Some important working principles include:

- Quality. As with many forms of computing, errors in essential components of a digitally based task can very easily multiply. At all times, when undertaking GIS work, maximum effort must be placed on: (i) achieving quality of inputs to the systems, (ii) high-quality functional data processing; and (iii) providing quality, accurate output.
- Cooperation. Work under his programme will rely on working with different sets of stakeholders, and with people and groups operating in different countries, perhaps under different rules and cultural norms. This is going to involve a great deal of cooperation and cooperative working. Cooperation is also required within one's own place of work.
- Compromise. There will be many times when differences of opinion will occur with regard to almost any aspect of the work. Progress will not then be possible without a degree of compromise. There may be winners and losers but it is important that someone is available who can act as a neutral referee.
- Trust. For much of the time work may be carried out in conjunction with people or groups with whom there is unfamiliarity. This means that trust must be given and accepted at all times. If there are doubts, then these should be raised with management.
- Sharing. Cooperation often means the need to share. This will be extremely important when working on MSP-related tasks where data resources especially need to be shared. Sharing is also very beneficial in terms of cost reductions made from, for example, sharing hardware or even human resources.

- Objectivity. This is a fundamental principle that should underlie all scientific work. It is particularly relevant to GIS, where it is important to take unbiased opinions with respect to findings based on map outputs.

**Sustainability principles**

With respect to this RECOFI spatial planning and management programme, many aspects of it have sustainability principles at their core. Sustainability principles include:

- Sustainability. This lies at the root of MSP and EAA/EAF, which itself is the main purpose for implementing spatially based planning and management. Thus, the specific intention is that spatial zoning takes place with the purpose of (i) creating idealized areas for the optimal and sustainable functioning of varied marine activities, and which (ii) allows for the EAA and EAF to best be operationalized.
- Replenishment. It is widely recognized that many marine areas/ecosystems are not functioning at their maximum rates of productivity. Through enhanced spatially based management, it is intended that marine productivity can be improved, leading to replenishment of a range of natural biological resources.
- Conservation. In the same manner as replenishment, much of the purpose of GIS is to lead to improved resource management. This may frequently require conservation of species, i.e. with a purpose of helping to save species or to provide enhanced food inputs along trophic chains. Much GIS work is now concerned with identifying sites for marine protected areas – areas that will be crucial to the improvement of marine resources in the Gulf area.
- Planning. GIS is an optimum tool for good planning, e.g. it can optimize locations for a wide range of structures or activities. Now that the era of MSP is so important, enhanced planning capability and principles will allow for improved decision-making.
- Waste reduction. At the heart of sustainability is waste reduction, including recycling. GIS use can give clues allowing for enhanced resource use and thus reduced resource extraction.
- Ecosystems functioning. As has been previously mentioned, the EAA and EAF are approaches to production that include wider ecosystems considerations. One area that this RECOFI programme will be concentrating on is the implementation of GIS to better (or more easily) allow social and economic factors to be included in fisheries or aquaculture planning or management. Thus, the EAA or EAF embody principles of sustainability (see Box 4).
- Spatial equilibrium. At the heart of most fisheries and aquaculture problems lies spatial disequilibrium, i.e. where the factors of production are out of balance and the ecosystem is in some way degraded. The use of GIS will allow the factors causing this imbalance to be identified, and this will contribute towards achieving the desired principle of maximizing spatial equilibrium.
- Regeneration. If EAA and EAF principles are followed, this should have a major impact in terms of both social and economic regeneration among communities involved in fishing and mariculture. This will allow for longer term viability of self-sustaining communities and help to provide incomes and food resources in more isolated rural areas. General principles underlying the EAA and EAF are provided in Box 4.

**BOX 4**
**The ecosystem approaches to aquaculture and fisheries**

The ecosystem approach to aquaculture (FAO, 2010), and the ecosystem approach to fisheries (FAO, 2003) have been developed in response to the need to implement, in a practical manner, the principles of sustainable development (WCED, 1987), the Convention on Biological Diversity (CBD, 1992) and the Code of Conduct for Responsible Fisheries (FAO, 1995). The EAA and EAF are consistent with all these principles and have been adopted by the FAO Committee on Fisheries (COFI) as the appropriate approaches to implement these principles for the management of aquaculture and fisheries.

**Ecosystem approach**
The ecosystem approach (EA) not only deals with all the ecological consequences of fishing and aquaculture, but it also explicitly deals with the social and economic implications (positive and negative) generated by the management and institutional arrangements. It works by the identification and assessment of all relevant issues and the establishment of participatory processes to help address high priorities effectively and efficiently. It assists with making the best decisions with the information available by using a precautionary approach (to reflect the risk) and an adaptive approach (to improve knowledge and adjust decisions). Implementing EA helps to develop holistic management systems that seek the sustainable and equitable use of the whole system (ecological and human) to best meet the community's needs and values.

**The ecosystem approach addresses both transboundary issues and scale issues**

• **Transboundary issues.** When the watershed boundaries or marine fishery areas extend beyond political boundaries, different authorities (or, in some cases, different countries) will need to be involved. The FAO Regional Fishery Bodies play an important role in this respect, as they can provide the political platform for the implementation of the EAA and EAF.

• **Scale issues:**
- Local fisheries or farm-scale. The individual farm or local fishery is often easy to locate and identify, and local effects are often easy to assess, although in cage aquaculture, especially in open ecosystems such as open seas, it may be challenging to establish the boundary of potential effects. Worldwide, most management practices are developed for this scale and most top-down regulation measures, such as environmental impact assessments (EIAs), apply at this scale.
- Watershed/waterbody aquaculture or fisheries scale. This geographical scale includes a cluster of farms, or fisheries that share a common waterbody, and that need a coordinated management.
- Regional scale. The regional scale may contain a number of waterbodies that are interconnected or transboundary and can benefit from planned and managed aquaculture and fisheries development from river watershed to marine waterbody.

Sources: FAO (2003, 2010).

## A SPATIAL PLANNING DEVELOPMENT PROGRAMME: PROGRAMME COMPONENTS, ELEMENTS AND ACTIVITIES

This regional workshop forms a major element in the RECOFI Regional Spatial Plan designed to introduce spatial planning into the planning and management of fisheries and aquaculture as practised in the Gulf. In order to fulfil the requirements of the elements shown in Box 1, Table 1 of FAO/Regional Commission for Fisheries (2011, p. 109) shows that the 12 elements are broken down into 30 separate activities. To achieve the objectives (purposes) of this workshop, these elements and activities have been subdivided into the following workshop Topic Areas, each of which represents a cohesive discussion package:

- Topic 1. Overseeing fisheries and aquaculture GIS work (Element 2; Activity 9).
- Topic 2. Capacity building for higher- and middle-level decision-makers (Element 5; Activities 15 and 16).
- Topic 3. Prioritizing GIS work and identifying pilot projects (Elements 7 and 8; Activities 18 and 19).
- Topic 4. Where, and how, will the GIS function best? (Element 11; Activities 25, 26 and 27).
- Topic 5. Practical training in GIS (Element 6; Activity 17).
- Topic 6. Identifying and acquiring data for GIS (Element 9; Activity 20).
- Topic 7. Updating and managing GIS data and information (Elements 9 and 10; Activities 21, 22, 23 and 24).

With respect to each of these Topic Areas, by the conclusion of the workshop, it will be necessary to have covered the following (generalized) material and considerations, plus the Topic-specific material and questions, detailed below:

- Provided an overview of what the Topic Area covers.
- Identified the level (or levels) (regional, national or local) at which the Topic might function best.
- Identified any lead groups or resource providers.
- Identified any marine fisheries or aquaculture specific requirements.
- Identified the time span for completion of the activity.
- Identified any gaps in the content of each Topic.
- Identified approximate costs associated with the accomplishment of each Topic Area.
- Discussed possibilities of resource sharing or cooperative working.
- Defined any major barriers to progress.

Information on the present status of many of these points will have been gained from the questionnaire survey completed by all RECOFI States earlier in the year. Further information will be obtained through workshop discussions and brainstorming. Each of the seven Topic Areas will have its own specific considerations. By the conclusion of this programme of work, all workshop participants should be confident that they are in a strong position to at least contribute to the start of a programme of GIS-based work.

### TOPIC 1. OVERSEEING FISHERIES AND AQUACULTURE GIS WORK
(Element 2; Activity 9)

**Introduction:** Element 2 of the regional programme for implementing a spatial planning strategy for the management of fisheries and aquaculture is concerned with establishing the overall capability, at a national level, of the means whereby spatial planning will adequately function and thrive. Earlier activities in this element consider priorities for marine management, and more especially how MSP will best operate in the RECOFI region, and then how the region may be partitioned in terms of competing marine activities. Arguably, the most essential of these marine activities, certainly in terms of numbers employed, space requirements and environmental quality considerations, are fisheries and

mariculture. The earlier sections of this document have outlined the plight of the Gulf marine waters in terms of providing sustainable deliveries of fish resources and, in order to improve this situation, spatially based planning and management via the use of GIS is recommended. This topic is designed to develop the holistic basis upon which GIS may best operate, probably as a major strand within a "Gulf MSP".

**Present status:** The questionnaire survey did not investigate this Activity of the Programme Component. However, judging from (i) the array of answers received to various sections of the survey, (ii) the present status of marine or fisheries/aquaculture-based GIS in most RECOFI countries, and (iii) the probable status of MSP adoption in the region, there will not currently be "national marine GIS committees" (or their equivalent) in any RECOFI country. Such a committee will be essential if (i) the marine space is to be adequately partitioned among competing activities, (ii) fisheries and aquaculture are to thrive sustainably, (iii) the marine environment and dependent ecosystems are to be enhanced, and (iv) spatially based planning for these themes is to be unified at the national and international level.

**Actions:** In the absence of information concerning advances that may have been made with respect to Activities 1–8 of the RECOFI Regional Spatial Plan, it will be necessary to include some preliminary considerations (actions) with respect to this Topic. Sequentially, the following are seen as the main inputs to accomplishing the aims of Activity 9:

a) Establish, at the highest decision-making level, whether progress has been made on adopting MSP based policies for the regional management of Gulf marine waters. If moves in this direction have been started, then is there a functional structure that describes its (their) operating modes?
b) If no regional progress has been made on MSP implementation in these waters, then steps might have been taken at a national level to implement an MSP functional structure in any of the eight EEZs of the individual RECOFI member countries. Again, what is this functional structure?
c) If again no national progress has been made on MSP implementation in EEZ waters, highest-level decision-makers at national levels who have a remit covering marine areas or activities need to contact other users of the marine space in order to work towards the integrated management of this space.
d) Necessary steps must then be taken to coordinate, at the regional scale, all necessary work to activate an integrated Gulf MSP.
e) Once agreement for cooperative working is achieved, the necessary management structures can be implemented. Part of the management structure needs to include a "regional marine spatial planning and management" committee having a defined remit and being comprised of stakeholders from all sections of marine users. As a subcomponent of this committee, there should be a "regional fisheries/aquaculture GIS committee" comprising representatives from each of the eight RECOFI countries. It is extremely important that this committee be led by a "GIS champion", someone who can ensure that adequate progress is made on the GIS work across all RECOFI countries in a unified way.
f) At a level below this committee, there should be a "national fisheries/aquaculture GIS management" committee comprising middle-level decision-makers plus interested coopted (or voted) representatives of all GIS workers. Details of such a committee cannot be proposed here. This committee would have a wide remit in terms of project selection, representation on higher-level committees, perhaps staffing and systems updates, training and support, etc. This committee should be led by a well-qualified and highly motivated "GIS champion", and a national representative from this committee should be elected for regional representation.

There is an extent to which all the Topics that follow this are dependent on this committee being in place. Having said this, if there is no such committee structure, then means must be found of working through the Topic activities in a considered and balanced way.

Programme workshop decisions/activities:

1. Discuss/agree/change any of the above actions.
2. Do attendees know if moves at regional or national levels have been made to implement MSPs?
3. Do any marine GIS committees currently exist?
4. What might be the barriers to forming them?
5. Are there organizations in your country that might represent other marine space users?
6. Are there foreseen barriers to cooperative working?

See also concept note on "Marine spatial planning in marine waters for the State of Qatar and three neighbouring countries" in Annex 1 of Appendix 9.

## TOPIC 2. CAPACITY BUILDING FOR HIGHER- AND MIDDLE-LEVEL DECISION-MAKERS (Element 5; Activity 15 and 16)

**Introduction:** It is initially important to clarify the distinction between Activities 15 and 16. Within any group engaged in production activities such as aquaculture or fisheries management, there will be a hierarchy of personnel involved. These broadly consist of highest-level decision-makers such as fishery ministers and other top decision-makers, middle-level personnel such as fishery managers and fishery researchers, and below them a mixed group of persons involved in doing the practical work to achieve the desired output that should assist in decision-making. At each hierarchical level, a different set of skills, knowledge and training will be required. Element 5 is concerned with higher-level (Activity 15) and middle-level (Activity 16) officials and managers (decision-makers) who must know about their subject to a different degree, i.e. so that they may successfully enable the production activity to continue.

Capacity building in the context of this workshop (and the Element) means that higher- and middle-level managers are made aware of the significant importance of taking a spatial approach to the management of fisheries and/or aquaculture, and indeed to the management of the wider marine area including its ecosystems and the range of activities carried out there. Thus, it has been shown that problems arise in marine areas when the natural ecosystems are out of equilibrium (i.e. in disequilibrium or "out of balance"), and this may be caused by natural events, e.g. climate change, or more frequently by a range of human activities being pursued in an unsustainable way. Several authors (e.g. Sale *et al*., 2011; Sheppard *et al*., 2010) have recently described a range of severe problems that are increasingly affecting the waters of the Gulf, and which are leading to a generally degraded marine environment. In the last decade, it has become increasingly clear that both MSP and EAF/EAA approaches are important spatially based means of addressing many marine problems, and these are both best addressed through the use of GIS.

Capacity building for highest-level decision-makers would be quite different from that required for middle-level personnel. Box 5 illustrates the main features of spatial planning that should be appropriately acquired by those decision-makers with high-level responsibilities. Thus, they have no need to know how GIS works or what specific functions it performs, what its inputs and outputs are, etc. Their requirements are to know: (i) the types of problems that GIS may resolve, (ii) what in basic terms GIS and remote sensing are, (iii) that spatial data are fundamental to the system, and (iv) some broad examples of the types of questions that may be addressed. On the other hand, for middle-level managers and researchers, their needs are much more directed towards: (i) the workings of the system including its inputs and outputs, (ii) the large variety of data requirements and sources, (iii) a wide sample of the functional analyses that are possible, and (iv) various factors relevant to running a GIS team. They must also have good communication and interpersonal skills. Box 6 illustrates more precisely the range of occupational knowledge required of middle-level decision-makers.

**BOX 5**

**Spatially based topics to promote capacity building for higher-level decision-makers in the fisheries or aquaculture fields**

- The importance of MSP and EAA/EAF approaches to marine management.
- Fisheries or aquaculture problems mainly have their roots in spatial imbalances among the production inputs.
- Satellite remote sensing can gather data from a wide area in a cost-effective manner, e.g. for water temperature, algal blooms, chlorophyll, sea cage locations. Remote sensing data can be used to plot and measure spatial changes over time.
- GIS has shown enormous success in a wide range of mainly terrestrial uses, but it is now being applied extensively in marine-related situations.
- Large amounts of suitable data for marine-based GIS are available in digital form via the Internet.
- GIS is the optimal tool for a large variety of analyses where spatial factors are involved. It allows for objective output to be achieved in tabular, graphical and mapping formats.
- Using GIS for marine or aquaculture work, decision-making is aided in many fields, e.g.:
  - zoning for aquaculture;
  - optimizing sites for aquaculture cages;
  - marine habitat mapping and analyses;
  - modelling of potential actions or scenarios;
  - monitoring results of management policies or of fishing effort;
  - analyses of ecosystem relationships;
  - marine spatial planning or activity zoning;
  - fleet disposition and fish yields.

**BOX 6**

**Main aspects of spatial planning that need to be conveyed to middle-level decision-makers**

- How the software elements work and are integrated to make a complete system.
- The operational requirements of all hardware, including networked elements.
- Know the basics of data sources, data inputs and data management.
- Have the ability to fully understand and clearly summarize any GIS analyses conducted.
- Have an understanding of all the main functional attributes of GIS (Annex 4).*
- Have an understanding of the main aspects of marine capture fisheries or aquaculture management that might require GIS project work (Annex 5).*
- Have some knowledge of map visualization, i.e. the requirements necessary to produce clear and effective mapping output.
- Recognize how their particular working role fits into the whole GIS project, and what the responsibilities of other team members might be.
- Have a good knowledge of channels of communication, including importantly who they need to be sharing data and GIS output with.
- Have the ability to discuss GIS-based output with other senior managers and external fisheries personnel.
- Etc.

* Annexes refer to those in the source document.

*Source:* FAO/Regional Commission for Fisheries (2011; p. 100).

**Present status:** Feedback from the survey questionnaire with respect to capacity building (see Tables 4a and 4b of questionnaire survey) indicate that at least five of the eight RECOFI countries require some level of capacity building, although information was not gathered enabling the exact nature of this to be isolated. However, it can be reasonably assumed from many answers to the GIS/spatial planning questions that a significant proportion of higher-level managers and decision-makers could benefit from a sound introduction to the planned spatial-management-based work. Moreover, given that middle managers need to be far more familiar with the spatial planning systems, the need for additional capacity building for them is certain to be beneficial and thus advisable.

**Actions:** Under the present Programme of Work, capacity building for higher- and middle-level decision-makers means that they should have basic familiarization with the items listed in Boxes 5 or 6 as relevant.

1. **Decision-makers at the highest level. (Activity 15).** Personnel working at this level will simply need to be aware of the advantages to be gained from spatially based decision-making – in this case in the context of marine, fisheries or aquaculture activities. For each RECOFI country, it would be important to identify the key ministries where high-level decision-makers are working, and who the important decision-makers are. A promotional leaflet (or set of leaflets) needs designing that explain the fundamentals of MSP, EAA/EAF, GIS and remote sensing, i.e. essentially the material covered in Box 5. Leaflets should be in at least Arabic[5] and well illustrated. It is most important that they be delivered or distributed in such a way as to ensure that they are read. This might well be accomplished by a senior worker with knowledge in these areas who could deliver a briefing on the importance of spatially based planning, i.e. perhaps in the context of any briefing required to introduce the RECOFI programme of work, or to introduce the necessity for MSP EAA/EAF approaches.

2. **Middle-level decision-makers. (Activity 16).** As for higher-level decision-makers, it will be important to identify work places for those at a middle level, and the individuals involved. It is probable that they will come from a wider range of organizations than those at the highest level. For relevant workers at this level, it is likely that they will be significantly involved with any of the spatial planning and analyses that take place. It will be important, therefore, that they have a greater knowledge of all aspects concerning spatial planning, especially those concerning the whole functional operation of GIS and data collection. It is suggested that a one-week regional workshop be organized to cover topics such as:
   - MSP;
   - EAF/EAA;
   - GIS and its functioning (including demonstrations of GIS functioning);
   - remote sensing and image analysis;
   - data collection and data management;
   - examples of marine-based GIS work.

   This workshop might be difficult to organize in such a way that all participants have “hands on” experience of all aspects of the work, but this should not be a requirement at this level. Participants would be supplied with material such as FAO Fisheries and Aquaculture Technical Paper No. 552 (Meaden and Aguilar-Manjarrez, 2013). Given space/number restrictions for any workshop, it might be necessary to run a workshop more than once, and consideration might be given to inviting workshop attendees from other sectors that use the marine space.

Programme workshop decisions/activities:

1. Discuss/agree/change actions 1 and 2 above. Are there alternative ways of informing decision-makers?

[5] Perhaps also in English and Farsi.

2. Are there non-governmental high-level decision-makers that would benefit from capacity building? Is it easy to establish work place origins of all potential decision-makers?
3. If leaflets are being used, should these be separate for each topic? Or one larger leaflet?
4. Language (or languages) of leaflets.
5. How long for a workshop (Activity 16)? Where might this be held? One workshop or more? Who should/could run the workshop? When to occur?
6. Who should attend Activity 16 workshop? Is the scope of the workshops wide enough?
7. Should any stakeholders working in other marine sectors (not fisheries and aquaculture) be invited to participate in the workshop?

## TOPIC 3. PRIORITIZING GIS WORK AND IDENTIFYING PILOT PROJECTS
(Element 7 and 8; Activity 18 and 19)

**Introduction**: There is little need to discuss the basic facts concerning this topic area as this is done in some detail in FAO/Regional Commission for Fisheries (2011, pp. 101–103). It should only be necessary here to state that it is likely that those who have worked in fisheries for some years will be aware of the main fisheries problems that need addressing in order to improve the status of this activity. Because it has been little practised in the RECOFI region, it is unlikely that there will be many workers in the Gulf States with knowledge of mariculture-based problems. As it is almost certain that any problems will have a spatial element, i.e. some factor of production (or production function[6]) will be in disequilibrium, there is a high possibility that GIS can be of use in resolving the problem. Increasingly, it is likely that the needs of the wider fisheries or mariculture communities will have to be considered when prioritizing GIS work, and this may entail either an EAA or EAF (see Box 7). It is also relevant to mention here that in FAO/Regional Commission for Fisheries (2011) both Activities 19 and 20 included the assessing of data needs for GIS. This is now covered only as part of Activity 20.

For smaller RECOFI countries, the task of prioritizing GIS work may be quite simple because it is likely that all GIS work will be confined to one office (or working group), and because there is relatively little marine geographic space that needs to be covered by any GIS project. For larger RECOFI countries, where GIS activities may be performed at several centres or where there may be a much larger range of spatially based problems, decisions need to be taken on whether GIS prioritization should be a local or a national-scale consideration. Moreover, as the RECOFI countries should be working together (collaborating and cooperating) in order to bring about improvements in the marine environment and to fisheries or mariculture, there could be priorities that are at a regional scale. However, it is strongly advised that priorities for initial GIS work should be kept to a small local scale, and work should not involve wider spatial planning, i.e. where more than one country is involved.[7] If additional information is required on the types of fisheries/aquaculture GIS work that are possible, then Meaden and Aguilar-Manjarrez (2013) provide numerous examples directly, or they refer to other sources from where examples might be obtained. In addition, the FAO GISFish website has a wide range of examples (see www.fao.org/fishery/collection/gisfish/en).

[6] Production functions are those factors or variables that, in various combinations, influence the success of a production activity, e.g. water quality will influence the success of aquaculture.

[7] Except in the case of Iraq, whose marine space (EEZ) is very small.

**BOX 7**
**Identification and prioritization of projects using the ecosystem approach for aquaculture and fisheries**

**Scoping and definition of the ecosystem boundaries**
It is initially essential to formally define the scope and scale of the fishing (and aquaculture) activities, communities, political and geographic areas that will (or will not) be covered by the project area. This may require clarifying any uncertainties about which agencies have management responsibility for the area and/or ecological resources under consideration.

**Identification of the issues and priorities for an ecosystem approach**
Based on the agreed scope of the aquaculture or fisheries system and the community values to be achieved, the next step is to identify and examine all issues relevant to aquaculture/fisheries, i.e. to decide where to focus the management system to generate the best community and sustainable outcomes. To assist with this process, the issues can be separated into the three EAA/EAF component groups:

1. **Ecosystem well-being** – All the relevant ecological "assets" (e.g. stocks, habitats, ecosystems) and the issues/impacts being generated that may be affecting them.
2. **Human well-being** – The social and/or economic "outcomes" currently being generated. These could be both good, i.e. those outcomes the community wants to have generated (e.g. food security, economic development), and bad, i.e. those it wants to avoid (e.g. conflicts, pollution).
3. **Ability to achieve** – The management and institutional "systems" in place or proposed to deliver the desired outcomes (e.g. access and tenure systems, compliance, democratic processes, conflict resolution), along with the external "drivers" (not controlled by management) that may be affecting performance (e.g. pressure from other activities).

**Identification of issues**
Based on the scope of the chosen aquaculture/fisheries activity and the geographical area, the next step central to the entire EAA/EAF process is to identify all the relevant issues (assets, outcomes, systems and drivers) associated with the fishery or aquaculture system across each of the EAA/EAF components (ecological well-being, human well-being and ability to achieve). The identification process must cover all direct and indirect impacts generated by the activity on the local environment and the broader ecosystem, plus the wanted and unwanted social and economic outcomes on both the fishers/farmers and the community. The process should also identify all the elements needed to enable the effective governance and administration of the fishery/aquaculture, including legislation, plans, consultation, compliance, etc. Finally, any issues external to the management system that could affect the performance of the fishery/aquaculture, including natural (e.g. climatic) and human-induced ecological (e.g. pollution), social (e.g. international attitudes) or economic (e.g. exchange rates) impacts, should be recorded.

**Prioritization of issues and risk assessment**
A large number of issues can be generated through the issue identification process. In order to determine their priority, it is essential to decide whether any direct management actions should, or should not, be undertaken to ensure the appropriate use of what are often scarce resources. Risk assessment methodologies are used because these directly assess the likelihood of not achieving acceptable performance against each relevant management objective. Because risk includes uncertainty, these assessments can be completed with few or no quantitative data. Risk assessment principles enable managers to make the most-informed decisions with whatever information is available.

**Identification of potential management measures or projects**
After identifying which priority "issues" (ecological, social, economic or institutional) require direct intervention, the next step is to identify potential management choices or systems that will deliver successful outcomes.

**Present status:** Tables 1 and 2a of the questionnaire survey show that some RECOFI countries have already identified, or have embarked on, or have completed, a range of GIS "pilot" projects, and most of these are summarized in Box 8. Tables 2b and 2c of the questionnaire further indicate that some RECOFI members have identified future potential thematic areas for GIS-related fisheries and/or aquaculture work (Box 9). It is clear that actions on this topic area in a few RECOFI countries are under way, although little progress has been made in Kuwait, Iran (Islamic Republic of) and Iraq, and little information has been supplied by the United Arab Emirates and Saudi Arabia.

**Actions:** Prioritizing the GIS work can be a challenge in the sense that priorities should be based on a range of considerations, as shown in Box 10. When any initial GIS work is being prioritized, it is essential that these factors are considered, so questions will need to be asked of the organization's ability to address these considerations. To do the prioritization it will be essential that a team is involved, i.e. the team discussed in Topic 1 above. This will need to be composed of at least: (i) GIS personnel, (ii) either or both of higher-level or middle-level fisheries/aquaculture management, (iii) perhaps an external consultant or adviser, and (iv) perhaps representatives or stakeholders from other activities being performed in the same problem/spatial area. According to the scale of the GIS-based project, this team could be local, national or regional in respect to its participants. Long-term experience of GIS implementation has shown that the most successful teams are those that are "championed" (led and encouraged) by a person who has exceptional qualities of enthusiasm, person management skills and a sound knowledge of GIS. Such a person should be actively identified. Hence, early actions will be to have a "GIS project selection", a "champion" and a team identified and available.

Pilot projects themselves will usually be selected from the list of prioritized GIS work,[8] and pilot studies may take the form of both experimenting with GIS capabilities, or obtaining examples of the types of output that might initially be achieved. It is assumed that the GIS technical staff has the required training to be able to perform all required GIS operations, including those associated with organizing and managing the necessary data. Results from pilot projects need to be carefully examined in terms of their credibility and, if this is considered to be satisfactory, the GIS should be shown and reviewed by a cross-section of middle- and higher-level decision-makers.

[8] This is not essential as a pilot project could be based on "copying" the work done in some previous fisheries GIS study, or it could be based on undertaking a deliberately selected simple GIS study.

**BOX 8**
**Completed, ongoing or planned projects in RECOFI member countries**

**Completed aquaculture projects**

- Identification of potential aquaculture zones along the Red Sea coast in Saudi Arabia using satellite image analysis and GIS and an estimate of sustainable carrying capacity.
- Oman has prepared an atlas entitled Atlas of suitable sites for aquaculture projects in the Sultanate of Oman"". The atlas contains satellite imagery and information relevant for site selection or suitability studies for aquaculture.
- Saudi Arabia has developed a database on locations of fish farms together with attribute information using a Google Earth application.

**Completed fisheries projects**

- The Bahrain General Directorate for the Protection of Marine Resources, in association with the GIS Directorate, Central Informatics and Telecommunications Organization (CITO), has undertaken a "GIS project" to collate all spatial information and represent the spatial information through a customized web application for query and analysis.
- Bahrain has collected marine capture fisheries data during its Marine GIS (MarGIS) Project, which is an online marine environmental GIS.
- Iran (Islamic Republic of) has implemented a web-based fisheries marine information system (FMIS).
- Iran (Islamic Republic of) has developed a national fishing ports GIS-based database.
- The FAO and the Iraqi Ministry of Agriculture managed a project titled "Towards sustainable development of **inland** fisheries in Iraq". This project has not been implemented.
- Oman undertook a remote sensing study of the movement of commercial vessels.
- Oman undertook a fish resources assessment survey to provide spatial habitat information.
- Oman has collected available remote sensing data such as SST, currents and Chl-*a*.

**Ongoing**

- In Qatar, a project titled "Sustainable Management of Fisheries Resources" is establishing an infrastructure for effective ecosystem-based fishery management in Qatar and the Gulf region.

**Planned**

- The Environment Agency of Abu Dhabi has identified a project and released a "request for proposals" for a study that includes an identification of suitable aquaculture development zones, exclusion zones, and ecological significance zones. The status of this project needs to be confirmed.

**BOX 9**
**Ideas for projects in RECOFI member countries**

**Aquaculture**

- Expanding the Saudi Arabia and Oman GIS studies to cover regional scoping for potential marine aquaculture in the RECOFI region. This will identify countries, culture systems and culture species that have the greatest potential in the region to allow prioritizing and coordinate planning.
- Replicating the Saudi Arabia and Oman GIS studies to other RECOFI countries to identify potential production and aquaculture zones for development.
- Creating an inventory of existing aquaculture installations with a database for licensed registrations, species, production systems, annual production, etc., that can link to national and regional statistics and aquaculture management.
- Spatial tools to improve national/regional disease surveillance, monitoring and reporting (i.e. follow-up work to Regional Technical Workshop on Aquatic Animal Health [in FAO/Regional Commission for Fisheries, 2009]). Also zoning of areas for aquaculture biosecurity management.

**Fisheries**

- Saudi Arabia. An online vessel tracking and monitoring system was indicated as a proposed project during the 2010 RECOFI spatial planning workshop.
- Creating an inventory of existing fishing capacity with a database for licensed registrations, species, production system, annual production, etc., that can link to national and regional statistics and fisheries management including fishers villages, landing areas, fishing markets, fishery catch and fishing effort.
- Fishing catch and effort analysis to identify where, when and how fisheries operate within a given area.
- Area characterization – identify the physical parameters (e.g. sediment type), biological parameters (e.g. species abundance), and regulatory framework within a selected area.
- Bycatch analysis – identify the trends in bycatch among different fisheries and gear types, geographic areas, time periods, depth ranges, and habitat types.

**BOX 10**
**Important considerations in selecting pilot GIS projects**

- The geographic area that needs to be covered.
- The urgency of the task.
- An appropriate scale to be working at.
- Familiarity with the production functions that may influence the problem.
- The data required, plus possible data sources.
- Are the data sufficiently detailed and accurate so as to provide reliable results?
- Does additional data need collecting?
- Should the work best be done in conjunction with a neighbouring area or country?
- The complexity of the GIS functions that may need to be performed.
- Is there expert advice (fisheries and GIS technical) available in the event of problems?
- How long will the project take to complete?
- Is the final output easily able to be understood, i.e. is it visually comprehensible?
- What is a reasonable work capacity, i.e. can two projects be undertaken at the same time (this can be beneficial in terms of staff deployment).

Programme workshop decisions/activities:

1. Discuss/agree/make changes to any of the above proposals.
2. Is there the capacity within each RECOFI country to reliably prioritize GIS projects?
3. What are the main problems foreseen (or already experienced) in the prioritization process?
4. Should all pilot projects be locally based or are there advantages to be gained by working cooperatively with a wider group? Are there benefits of developing generic methodology so that the results are compatible with other country projects?
5. Is it necessary to have both fisheries and mariculture pilot projects?
6. Is there available and reliable expertise to advise on the GIS technology and on the validity of the GIS output?

## TOPIC 4. WHERE, AND HOW, WILL THE GIS FUNCTION BEST?

(Element 11; Activities 25, 26 and 27)

**Introduction:** It will be important that any GIS is located at an appropriate location. The decision on where best to locate should result from a number of important considerations such as:

- Where can the necessary inputs to optimum GIS functioning best be assembled? This will include data resources, personnel, fisheries or aquaculture expertise, access to advice, etc.
- Is there already a location where a marine or fisheries/aquaculture-based GIS work is being successfully undertaken?
- Should the GIS operations be taking place at a number of locations? This could be based on perhaps a fisheries-based GIS at one location and an aquaculture GIS at another, or it could be based on the need for localized GIS bases, e.g. Saudi Arabia might have a Red Sea GIS and a Gulf GIS.
- Could the GIS operations best be shared with a neighbouring country or with another similar type of user, e.g. a marine, environment, or natural resources GIS?
- Could fisheries/mariculture GIS work successfully be added to existing IT work in perhaps a government office, i.e. without overloading the IT systems (mainly in terms of hardware requirements and personnel)?

Other important considerations relate to how the GIS might function best at any location. Perhaps of pre-emptive importance are the personnel involved, although it will also be necessary to consider factors such as the existing computer hardware, software, IT capacity and needs requirements. This will involve questions such as: Is there capacity to increase computing use?; Do existing employees have GIS skills?; If not, how will these be obtained?; What GIS software to use?; What hardware configurations?; Will the introduction of a new activity intrude too much on existing personnel and their work practices?. Meaden and Aguilar-Manjarrez (2013) provide further details on GIS implementation considerations. It will also be necessary to identify the remit at each GIS work location in terms of what the range of tasks will be.

**Present status:** The questionnaire survey (Table 5 of the questionnaire survey analysis) provided scant information on where and how any fisheries or aquaculture GIS might function best within individual RECOFI countries. Only Qatar seems to have adequately addressed this matter, although Oman has partially addressed the matter in respect of its marine fisheries. Other countries either failed to adequately address the question, or they omitted to supply answers at all, or, as they had no functioning marine fisheries or aquaculture GIS potential, the question had not arisen.

**Actions:** The result of answering the five questions posed above **(**under the "Introduction" subheading) should serve to satisfy the decision on where any GIS might operate best. Having established optimum locations for GIS work, there is a need to carefully consider the scale and the architecture for the whole GIS operation at each location. Both of these might be difficult to establish initially, but this is not too much of a problem because systems can readily be expanded or enlarged. At a minimum scale, a fully functioning GIS can be based simply on one trained worker plus a minimum set of hardware

and software. Minimum hardware requirements are those items that together constitute a local area network (LAN), i.e. perhaps consisting of a high-capacity computer, a colour printer, file backing-up hardware, an uninterruptable power supply plus Internet access. From this basic hardware, any system can be added to as and when required.

As well as hardware considerations, a GIS software package must be acquired. The decision on what software is best deployed could be quite complex. This is because there are four fundamental paths that could be followed, i.e.: (i) using so-called "free-ware" or "free and open source software" (FOSS), (ii) using a major proprietary system, (iii) using a cheap proprietary system, or (iv) using a dedicated marine/fisheries GIS package. It is difficult to advise on this, but these options are described in more detail in Meaden and Aguilar-Manjarrez (2013), and professional advice might need to be obtained that can advise on the local IT considerations. In many cases, the decision might have previously been made as there will already be a GIS in operation.

There are a number of other actions (or system requirements) that need consideration under this heading, and these are listed in Box 11. It is most important that all of these factors are carefully considered, because if any of these fail to be properly deployed then the GIS may be vulnerable to failure. Of particular importance to GIS success is the direct management of the GIS work. Thus, it has been found that GIS work is most likely to be successful if the manager is naturally enthusiastic with respect to what he/she is seeking to achieve. Moreover, because both GIS and fisheries/aquaculture are such wide-ranging topics/activities/processes, it is vital that the manager has an extensive background, preferably in both of these areas. So, it will be essential that the manager:

- can perform all the operations and GIS functions;
- has a good working relationship with higher-level management;
- is able to understand whether GIS output is reliable, i.e. in case operations have not been undertaken correctly or input data are inaccurate;
- is sympathetic to the demands of co-workers;
- is able to arrange for additional training, data sets, capital investment per worker, upgrading of systems, etc.;
- is fully up-to-date on new trends within the GIS and IT spheres.

It is also vital that the range of spatially based management work to be carried out at each identified GIS location has been decided upon. Thus, it is likely that if more than one GIS centre is established, which is quite likely in the larger RECOFI countries, there must be a basis on which the work will be partitioned. This could be strictly on a regional basis whereby all fishery or mariculture activities carried out in specified geographic areas are covered by a single "office". Alternatively, this decision may be made on the basis of specific expertise at certain locations, or the fisheries GIS work might be separated from the mariculture GIS work. The basis of this work division (if required) needs careful consideration because of the additional resources that might be required.

**BOX 11**

**Main considerations in designing a suitable GIS architecture**

System requirements and design involve a careful analysis of at least the following:

- GIS rooming accommodation;
- the likely amount of future GIS-based project work in terms of quantity and complexity;
- hardware requirements;
- software requirements;
- system architecture and design/distribution network;
- personnel requirements;
- data requirements (see Element 8);
- availability of technical support;
- capital investment per worker and running costs;
- constraints, challenges and risks associated with the GIS work.

*Source*: FAO/Regional Commission for Fisheries (2011; p. 117).

Programme workshop decisions/activities:

1. Discuss/agree/make changes to any of the above proposals.
2. Who will best decide where any GIS unit might be located and will this be an easy decision?
3. Should the options of joint working with neighbours be investigated, e.g. Kuwait with Iraq, or Bahrain with Qatar?
4. How might an appropriate manager be obtained? Or is there already such a person (or persons) available?
5. Will it be necessary to implement a GIS from scratch? Is there the knowledge or are there procedures by which this is done?
6. Will there be a need to be a separate mariculture GIS and a fisheries GIS?
7. Could MSP work be incorporated into a fisheries/mariculture GIS, or is this work likely to require separate facilities?

## TOPIC 5. PRACTICAL TRAINING IN GIS

(Element 6; Activity 17)

**Introduction:** It is clear that advanced digital systems such as GIS cannot function without workers trained in its use. In some cases, it might be appropriate (or possible) to obtain previously trained GIS personnel, but it may often be necessary to provide various amounts of training either in specific brands of software, or in specific aspects of individual programmes, or in operating tasks that may be distinctive to marine/fisheries work. Also, it will often be the case that workers may have adequate IT training in non-GIS programmes but may then wish to increase their range of computing skills. Whatever the reason, it is likely that some GIS training will be necessary.

**Present status:** Results from the questionnaire survey indicate a strong need for some level of GIS-based training among most of the RECOFI countries, i.e. with at least six countries indicating that this is required. Thus, a general demand for training is established. However, as noted in the analysis of the questionnaire (Table 4a), the survey itself "cannot indicate the precise extent of the training needs, and these are likely to be highly variable among RECOFI countries where the extent of marine activities themselves are similarly variable". Activity 17 covers two closely related GIS areas, i.e. that of identifying appropriate sources of training for GIS and that of delivering the training, and these can best be examined together. Information in Table 4a indicates that only two RECOFI countries (Qatar and Oman) appear to have the capacity to provide some appropriate GIS training, but as the extent of the necessary training could be highly variable, then it is difficult to state whether complete training

needs could easily be met. Thus, at present, three possible local sources of GIS training have been identified:

- in Qatar via the Centre for GIS in the Ministry for Municipality and Urban Planning;
- in Oman via facilities at the Sultan Qaboos University;
- the possibility of ESRI-based commercial type training in several of the RECOFI countries.

**Actions:** To further advance the matter of GIS training, it will be necessary to undertake at least the following tasks – initially almost certainly at the national level:

1. Arrive at solutions to both Topics 3 and 4 above. Resolving of these work programme areas means that a good indication will have been derived of the likely scale of future GIS work and a clear indication of where any GIS work will function (take place) at the national level. Thus, it is important to have some ideas in respect to general GIS needs, and thus strong clues as to specific GIS training needs.
2. To identify who is in need of training, it will be necessary to identify the availability of personnel having previous GIS training who might be locally available, or personnel who might be interested in training, or the need to appoint such personnel.
3. Based on the work programme areas to be covered, establish the ability of the personnel to undertake any desired GIS tasks. Assess what further GIS training requirements are needed.
4. Collate the information gained in point 3 on a RECOFI regional basis. Once this is done, it will be necessary to assess the regional demands for GIS training and relevant recommendations will need to be made.
5. It is difficult to take matters further here because the questionnaire survey analysis indicates that regional training demands will be highly variable. They will vary from being very small and specific requirements, i.e. that might be accomplished in a matter of hours, to complete GIS training that could take several weeks.
6. It will then be necessary to seek the required training via any of the following sources:
    - the three sources identified under "Actions" above (Qatar, Oman and ESRI);
    - short-term on-the-job training from perhaps another local GIS user who is perhaps working in a completely different field;
    - recourse to "distance learning" that is offered by various universities;
    - the organization of dedicated marine GIS training through perhaps an extended course organized through this current RECOFI programme (possibly delivered by the FAO).

Additional information on practical training in GIS is described in concept note on "Provision of GIS training for RECOFI member countries personnel as required" in Annex 1 of Appendix 9.

Programme workshop decisions/activities:

1. Discuss/agree/make changes to any of the above proposals.
2. Are there additional sources of training that were not previously identified?
3. Is it best to agree on the use of a unified GIS software?
4. What is the likelihood of any local organizations contributing to GIS training?
5. Is there a maximum (or ideal) length for training courses?
6. Is it best to offer training to existing personnel or to hire personnel already with GIS skills?
7. Might there be an initial necessity to partake in remote sensing training?
8. What are the costs of training – at the national or RECOFI area level?

## TOPIC 6. IDENTIFYING AND ACQUIRING DATA FOR GIS
(Element 9; Activity 20)

**Introduction:** It needs to be stated here that data are probably the most expensive input to most GIS work, with estimates that data costs can represent > 80 percent of the entire costs of a GIS project. Considerable efforts must be made in assessing the data required, in searching for data, acquiring data, filing data, plus a range of editing, updating, converting and data formatting tasks. The concern in

Topic 6 is with identifying, sourcing and acquiring any data needed. The nature of these data will depend on the production functions that control the spatial problem being addressed. For example, if GIS were used to develop models that best describe where a specific fish species prefers to live, then data would be needed on the distribution of the production functions (factors) influencing this. In this case, the main factors are likely to be water depth, water temperature, water salinity, perhaps bottom sediment type and food availability. The exact combination of these factors is likely to vary with the age of the fish being studied as most species have spawning, nursery and adult habitats. Boxes 12 and 13 illustrate the main production functions that might generally influence marine fisheries and mariculture, respectively, and thus they give clues as to the main types of data needed. However, what is not included here are any data in respect of the wider social and economic factors concerned with fisheries or aquaculture. Thus, if an early start is to be made with EAF or EAA work, this may greatly increase the range of data needed. A similar reasoning will apply if any GIS project work is concerned with MSP. As implied by these various examples, identifying data needs almost always relies on a good knowledge of the science (or processes) that underlie a problem, and on the types of data that best contribute to the science or to the process. Therefore, the aims for this topic are to be able to have access to the expertise allowing for data needs to be assessed, and to have sufficient knowledge of appropriate data sources.

The range of data sources might be large and, again, this is discussed in some detail in Meaden and Aguilar-Manjarrez (2013). Many of the data needed for fisheries and/or aquaculture work will have been collected by fishery-related institutes or organizations (including government departments, fishery research centres, or by private fishery or aquaculture companies or consultants). If the data are held by government, they will usually be easy to access (and acquire) as the costs may already be covered. It is likely that government agencies will also hold useful data such as topographic mapping outlines or hydrographic data (including information on bottom sediment types). Meteorological institutions will hold climate- or weather-related data that could strongly influence certain fishery or aquaculture activities. Large amounts of data are held by sources supplying remotely sensed (mainly satellite) imagery. These data cover topics such as surface water temperatures, water productivity, water turbidity, location of algal blooms or water temperature fronts, and some of these data are available in real time.[9] It is also likely that there will exist regional organizations such as ROPME (Regional Organization for Protection of Marine Environments) that should be able to advise on the availability of marine/fisheries data for the Gulf area (see www.ropme.org). In many countries, quite detailed fisheries data are now being collected via the use of electronic logbooks. This means that (usually larger) fishing vessels are equipped with digital software that, for every fishing trip, can capture data on fishing methods, amounts of each species caught, location of catches, quantity of fish discarded, port of landing, etc. The Internet provides an extremely convenient means by which data searches, and thus sourcing, can be carried out. Knowledge on data sources mostly accrues over time, and careful records should be kept regarding this.

It is also important to note that each of the production functions that may contribute to the spatial analysis being performed (or to the GIS-based project being undertaken) could be of different importance to the outcome of the project. In practice, this might mean that, in performing the GIS analyses, a weighting might have to be applied to each production function according to its perceived or calculated importance to the success of the activity, process or results. For example, if the project were aimed at searching for optimum marine habitats for specific fish species, then factors such as water depth, water temperatures, salinity values, and bottom sediment types might all contribute to optimum locations, but their contributions would not be of equal importance. Using various statistical techniques, it is possible to evaluate the relative importance of each production function, and the statistical results obtained would be used as the basis for developing weightings. With respect to aquaculture, the range of weightings could be quite large because this activity may have to take into considerations a range of terrestrial and/or aquatic zoning rules, plus regulations on what activities

[9] This means that the data are available very soon after being captured via satellite-based remote sensors.

aquaculture can best integrate with, plus any risks associated with certain areas. In an era when EAA/EAF and MSP approaches to fisheries and aquaculture are becoming the norm, the task of assigning weightings to production functions is likely to become more complex and more important.

**BOX 12**
**Some important spatially variable production functions influencing marine fisheries**

Only a limited range of the more important functions are illustrated here.

- **Bottom sediments –** The distribution of many demersal and benthic species is defined by bottom sediment types. This will affect the types of fishing gear used.
- **Bathymetry –** Different species are physiologically adapted to live at different water depths.
- **Salinity –** Different species are also adapted to different salinity levels, although some living in tidal zones can tolerate wide variations.
- **Chlorophyll –** The abundance of these algae can be a good indicator of water productivity.
- **Bed shear stress –** This indicates the current speeds on the sea bed and it strongly influences marine benthic (sea bed) assemblages.
- **Water temperature –** Again, physiological adaptations are made to water temperature. Seasonal variations can encourage migrations.
- **Thermal fronts –** These occur where bodies of relatively warm water meet colder water. High productivity along these fronts encourages feeding by pelagic species.
- **Species distributions –** These are highly variable both spatially and temporally, and will affect the distribution of fishing effort.
- **Nursery or spawning grounds –** Once identified, it is often essential to give some protection to these areas.
- **Marine vegetation –** Kelp forests, seagrass beds, coastal mangroves, etc. may all offer unique and important habitats.
- **Migration routes –** Species at higher trophic levels often make major migrations in response to water temperatures, spawning and/or food needs.
- **Predators –** Some areas have significant numbers of bird, fish or mammal natural predators, e.g. seals and marine sea birds.
- **Distance from port –** Fishers will try to minimize fuel costs by fishing as close as possible to home ports. Some ports act as major markets.
- **Fishing systems –** These may vary greatly at macro- and micro-scales.
- **Fishing effort –** The amount of fishing taking place in a given area over a given period. It may be measured in fishing days at sea, or engine capacity, etc.
- **Catch distribution –** This is typically measured by species per unit area for a period.
- **Fish values –** Prices for different catch species may vary significantly, and this can affect the fish species targeted.
- **Prevailing regulations –** Most marine fisheries operate within defined areas that have prevailing regulations that may significantly affect fishery activities.
- **Conservation areas –** Various by-laws will operate in these areas, which will usually restrict fishing effort and catches.

*Source:* Meaden and Aguilar-Manjarrez (2013).

**BOX 13**
**The main spatially variable production functions influencing marine cage culture**

- **Distance from shore (ports) –** This is important in respect of frequent observation, feeding, stocking, harvesting activities and other servicing activities.
- **Water depth –** Sea cages must be moored, and deep water presents a challenge.
- **Water temperature –** Species will have developed preferred temperatures and temperature tolerance ranges.
- **Availability of shelter –** Cages in open waters are vulnerable to storm conditions that can cause cages to break free, or break up with subsequent stock losses.
- **Distance from competing water activities –** It is essential to avoid siting cages in busy sea areas, or areas liable to pollution.
- **Water quality –** Many near-coastal sites may suffer from various forms or sources of pollution, e.g. oil leakages, sewage outfalls, or sources of disease. Dissolved oxygen levels are also important.
- **Turbidity and suspended solids –** Some species have preferences for clearer waters, e.g. away from wadis and wadi outlets.
- **Interactions of farm sites with immediate environments –** Cage siting needs to be aware of local biodiversity, waste deposition, sensitive habitats and sensitive species and benthos issues.
- **Distance from other cage farms –** Because of disease problems, cages are preferably located in relatively isolated and well-dispersed locations.
- **Prevailing wave heights –** Where long fetches prevail (usually around open oceans), prevailing waves may be too high for conventional cages, though completely submerged cages may be possible.
- **Availability of infrastructure –** Roads, electricity, communications, etc.
- **Availability of inputs –** The location of marine cages should be chosen in respect of important inputs such as extension services, veterinarians and feed suppliers.
- **Predators –** In some areas, predation from cages is a problem.
- **Visual impacts –** Cage locations should not be visually intrusive.
- **Exclusion zones –** Areas where aquaculture should not be placed (security and border areas, marine protected areas, etc.).
- **Avoidance zones –** Areas where there are known risks that could affect aquaculture (e.g. areas with high frequency of harmful algal blooms).

*Source:* Adapted from Meaden and Aguilar-Manjarrez (2013).

**Present status:** Analysis of the information secured from the questionnaire survey (Table 3a) indicates that five RECOFI countries (Bahrain, Iran [Islamic Republic of], Oman, Qatar and Saudi Arabia) have already accumulated varying amounts of data suitable for GIS use. However, it is extremely difficult to generalize on the utility of these because most of the data appear to be specific to particular projects. This is frequently a problem for GIS work and it may only be general data such as coastlines and bathymetry, plus a range of remotely sensed data that can potentially be used on many different projects. The situation with regard to the sharing of data appears to be highly variable in and between the RECOFI countries (Table 3d). Only Qatar implied that data might be readily shared among the countries, i.e. as many of them are freely accessible over the Internet. In some countries, sharing was possible although there were reservations about this, and various types of access permission might be needed according to the data source and type. In other countries, only restricted data sharing seemed possible, e.g. in Saudi Arabia and the United Arab Emirates, and in Iraq and Kuwait the topic of data sharing appears not to have arisen.

**Actions:** Most action on this topic cannot reasonably commence until after GIS project work has been prioritized (Topic 3 above). By then, it will be necessary to have the work team in place that has identified priority GIS work and pilot projects, and it should be in a position to advise on data needs and data sources. However, at a very early stage in GIS implementation, it would be advisable to start the search for appropriate data sources, including sources of information on companies, people, groups, government departments, fishery organizations, etc, that might be able to advise on data sourcing. Moreover, it can quite easily be ascertained as to which are the more general data that might be needed (Boxes 12 and 13), and these can be reliably collected at a convenient time.

Almost all data will be collected in a digital format. These data can commonly be collected by downloading via the Internet from the appropriate data source, or they might be acquired via CD–ROMs or DVDs. However, it is important to mention that there is still a large amount of older data that only exist in a paper-based format, e.g. especially mapping data and past records on, for example, fish catches, fish sales, vessel registrations, and fish markets. While the old mapping data will usually contain some form of inherent georeferencing (allowing them to be easily converted to a digitally mapped format), other kinds of usually tabular data cannot be used unless they have some form of georeferencing (post or zip codes, town or village names, latitude or longitude references, etc.). Conversion of older paper-based maps into digital formats is achieved by the use of scanners and/or digitizers, details of which can be found in Meaden and Aguilar-Manjarrez (2013). Paper-based tabular data need to be converted to digital format via entry of the data into spreadsheets such as Microsoft Excel.

There could be many occasions when the necessary data for GIS projects do not exist. This often means that the data need to collected, quite frequently from the marine environment. Means of original (or primary) data collection are covered in Meaden and Aguilar-Manjarrez (2013). It would be wise to ascertain whether or not there are provisions in each RECOFI country to actually collect new data. If marine-based data are required, these can be expensive to collect in terms of time, costs of a survey (or other) vessel, and any equipment needed. Moreover, data collection strategies have to be carefully considered.

Programme workshop decisions/activities:

1. Discuss/agree/make changes to any of the above proposals.
2. What are seen as the main barriers to identifying data needs?
3. Is your country (or organization) happy about data sharing with other RECOFI countries or local organizations?
4. Do you anticipate having to make an early start on MSP or wider EAA/EAF activities?
5. As in Topic 5 above, is there reliable expertise available to advise on data needs, sources and collection?
6. Do you have the means of collecting additional marine-based data if or when necessary?

## TOPIC 7. UPDATING AND MANAGING GIS DATA AND INFORMATION

(Elements 9 and 10; Activities 21, 22, 23 and 24)

**Introduction:** Reliable and accurate GIS-based output is almost totally dependent on having good-quality data to input into the system. It is thus an extremely important duty of some GIS personnel to be responsible for the good upkeep and management of all data held. This will usually require that database management systems (DBMS) are available. It will also be essential to ensure that the means are at hand to keep up-to-date with future or progressive developments that are occurring in the realms of GIS and with fisheries/aquaculture in the local area and perhaps the wider region.

**Present status:** An analysis of current post-collection activities for data management, as derived from the questionnaire survey (Table 3b), reveals that Qatar and Iran (Islamic Republic of) appear to update and/or edit many of their data, and that Bahrain and Oman do this differentially. In practice, almost all relevant data held will probably need to be verified as to its current usefulness. The questionnaire

analysis (Table 3c) further shows that all RECOFI countries, except for Iraq, Kuwait and Oman, have some kind of DBMS that can be used for fisheries/aquaculture GIS purposes, which presumably means that there are staff trained in their use. The survey questions did not request information about keeping up-to-date with trends in GIS and fisheries/aquaculture and having knowledge of information sources on this, or about compiling archives of useful materials.

**Actions:** Given the relatively few actions that may have taken place to date with respect to data updating and management, it is suggested that all data should be scrutinized before they are used. The upkeep of the data will involve a range of tasks including:

- Recording the origins, formats, variables covered, etc. of all data obtained. This is known as establishing a meta-database. Metadata is "data about data". It is important that accurate records are kept so that enquiries can be made to the data suppliers, that the means of data collection are known, and so that the original age of the data sets can be confirmed, etc.
- Where possible, checking that the data are comprehensive and is correct – editing the data will often be necessary.
- All data sets obviously age (at variable rates), and updated data may need to be acquired.
- Data need to be sensibly organized in terms of files, folders and other means of organization so that data can be readily retrieved.
- DBMS need to be understood and they offer the ability of undertaking most of the editing and organizational functions.
- Data security must be observed and appropriate measures installed including passwords and a record of who is allowed access to data sets.
- Putting a clear set of rules and systems in place so that the correct working procedures are always followed.

It will usually be necessary to have one member of staff in charge of data storage and upkeep. Depending on circumstances, data upkeep might be the sole occupation of that person, although in smaller GIS environments this work would form part of a wider range of duties. A DBMS may need to be secured by countries or organizations not yet having one.

With respect to information (rather than data),[10] an essential component of all GIS work is to keep up-to-date with trends. These trends will relate to developments in both GIS and in fisheries and/or aquaculture, and perhaps remote sensing, and it may involve reading/research by the manager and perhaps selected personnel. Keeping up-to-date will involve acquisition, storing and reading of information. Material may be either digital or hard copy (books, journals, reports, etc.). Most material will be located via digital means, usually via the Internet, using various search commands or going via specialist information sources such as GISFish and GeoNetwork. Systems must be developed for the distribution of relevant materials to appropriate staff members and for the digital and hardcopy archiving of materials.

Programme workshop decisions/activities:

1. Discuss/agree/make changes to any of the above proposals.
2. Is it easy to envisage how the editing and updating of data will fit into the way your GIS is likely to be organized?
3. Is there access to advice on using DBMS?
4. How will shared data access be organized?

[10] Data are raw facts that have been gathered, often through some kind of survey or sampling, and a special database might have been set up to record the data. By contrast, information is data that has been organized or processed, e.g. so that it is readily (or actually) produced in graph, tabular or mapping formats.

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**Annex 1**

## CONCEPT NOTES FOR PILOT PROJECTS ON MARINE FISHERIES AND AQUACULTURE

### REGIONAL SPATIAL PLANNING PROJECTS

**Project title**: Marine spatial planning in marine waters for the State of Qatar and three neighbouring countries

**Background:** Work carried out at both of the Doha and Cairo spatial planning workshops led to an agreement that the best means of revitalizing marine capture fisheries in the Gulf, and of establishing locations for marine-based aquaculture facilities, was through spatial planning with the support of geographic information systems (GIS) and associated technologies as a means of (and as the basis for) spatially based management. It was also agreed that ecosystems approaches to aquaculture and fisheries (EAA/EAF) as well as marine spatial planning (MSP) are essential frameworks/processes to support the implementation of MSP.

Fish and fishery ecosystems do not recognize national boundaries. It will therefore be essential that eventually the eight RECOFI countries work cooperatively to ensure the sustainable development of fisheries and aquaculture. This is especially important in the Gulf area where some national exclusive economic zones (EEZs) are relatively small and thus occupy only fragments of some ecosystems. However, the marine areas in which the fisheries ecosystems exist are also used for other purposes; these include marine shipping, energy extraction, recreational angling and boating, resort and other coastal urban developments, conservation areas, military zones, etc. Participants in all of these uses also have a right for their activities to be sustainable. In order that this can happen, the only practicable way ahead is for “user zones” to be amicably identified within RECOFI water areas. Such zones need not be exclusively the domain of any single activity, e.g. recreational boating may share most Gulf waters with fishers, and many licensed oil extraction areas could also be fished. It would be anticipated that fishers would retain rights to fish in at least 75 percent of the Gulf marine space.

**Justification:** Each RECOFI member country operates capture fisheries that have different characteristics, including scale, fishing methods used, species targeted, prevailing habitats and ecosystems, etc. However, all RECOFI member countries share in common the fact that many of their marine biological resources are widely perceived to be in decline or are becoming degraded, and many of the RECOFI member countries have a strong historical cultural connection to their marine biological resources. Therefore, there is an urgent need to solve this situation to ensure the longevity of these resources. Only by doing this will there be the possibility of continuing employment of artisanal fishers and, thus, the sourcing of incomes through the sustainable exploitation of sea food commodities for consumption or sale. An added significant benefit of such actions is the step toward sustainable management of domestic maritime food production/exploitation. Several RECOFI member countries have launched major food security programmes to reduce reliance on food imports and improve the principle of domestic self-sufficiency. As implied in the background section above, for an enclosed sea such as the Gulf that is shared by eight RECOFI member countries, it is essential that full cooperation is attained between nations if the capture fishery resources are to be sustainably exploited and if mariculture facilities are to be suitably located.

However, there is a need to think more widely than this. Each RECOFI member country will have an interest in maximizing its own marine resource uses and in ensuring that all users of the marine space are able to legitimately and sustainably carry on their activities in a way that does not impede on the reasonable use of the marine space by other sectors (energy, recreation, shipping, etc). Only in this way can just and equitable access to marine resources be achieved. However, the Gulf is a restricted, enclosed area, most marine resources do not conform to human imposed boundaries, and some of the

national territorial waters are very restricted in area. Therefore, it is in the interests of all States and user sectors to collectively secure this same equitable access to what are often common marine resources. The best way of obtaining equitable access to the marine space and the resources provided is through MSP, and as the optimization of marine space is best achieved through spatial zoning, it follows that GIS-based technologies are likely to be ideal for the zoning that underlies the MSP process.

Marine spatial planning is a well-documented public process in which all users of the marine space cooperate for the benefit of all. It involves significant preparatory work in matters such as identifying all legitimate users of the collective marine space, identifying their needs for this space, establishing agreed spatial zoning for either individual resource use or defined multiresource use, and for establishing systems of monitoring and control. All of this must be set firmly within a multinational legal framework with the necessary recourse to agreed judicial practices. Although the MSP procedures might initially seem large and complex, for the future success and sustainability of all marine activities, it is a process that is not only essential but it should contribute towards the means whereby RECOFI countries will better function cooperatively in a practical working environment.

However, before a Gulf-wide MSP is developed, it will be useful to carry out a pilot project to work out how best to implement MSP at a national level. Qatar has been selected as the country most suited for the task. This selection is based upon the fairly restricted size of the marine area, the fact that the country is well advanced in terms of information technology (IT) skills and provision, including much experience with GIS work, the availability of a wide range of suitable spatially referenced data for the marine area, and the fact that some data and expertise can be utilized from neighbouring countries, i.e. as a means of promoting cooperative work. In the future, it is likely that most of the eight RECOFI member countries will wish to develop MSPs for their own territories, and the zoning then established should feed into the regional MSP.

**Objectives:** To ensure that a successful approach to MSP can be achieved in Qatar in order to promote the development, conservation, rational management and best utilization of living marine resources, as well as the sustainable development of aquaculture, i.e. such that the experience gained can later be transferred to the rest of the RECOFI countries' territorial waters so as to form a Gulf regional MSP. This means that each member country has the necessary measures in place to ensure that all RECOFI water-area users are able to carry out their activities in a legitimate and sustainable manner.

**Geographical area:** The southern Gulf, comprising the EEZs of Bahrain, Qatar, Saudi Arabia, and the United Arab Emirates.

**Programme of work**: It should initially be appreciated that much of the work described here will not be carried out under the auspices of this particular RECOFI spatial planning project. Where the responsibilities will lie for this work is a decision that is beyond the scope of this concept note, i.e. the responsibility will mainly lie within the remit of a high-level government body concerned with marine resources, probably the Ministry of Environment in Qatar working with FAO. However, it should include persons having spatial planning and/or GIS experience. It is also beyond the scope of this concept note to give much detail on the step-by-step approach to MSP that is required for the process to be successful. Instead, here it might be useful to simply state the ten steps towards successful MSP as outlined in Ehler and Douvere (2009):[1]

1. Defining the needs and establishing the authority to carry out MSP.
2. Obtaining financial support for the process.
3. Pre-planning for the process.
4. Defining stakeholders and organizing their participation.
5. Defining and analysing existing marine-use conditions.
6. Defining and analysing future marine-use conditions.

[1] Ehler, C. & Douvere, F. 2009. *Marine spatial planning: A step by step approach toward ecosystem-based management.* Manual and Guides No. 53, ICAM dossier No. 6. Paris, Intergovernmental Oceanographic Commission.

7. Developing and approving the spatial management plan.
8. Implementing and enforcing the spatial management plan.
9. Monitoring and evaluating performance of the plan.
10. Adapting where necessary the marine management processes.

The MSP programme as devised for this spatial planning concept note assumes that there will be "national marine fisheries and aquaculture GIS" committees to oversee both fisheries and mariculture spatially based work, and it is likely that other users of the marine space (energy, recreation, shipping, etc.) may also have GIS representatives who can join with a fisheries/aquaculture representative so as to form "national marine GIS committees" in each RECOFI country. It is also assumed that, eventually, at least one representative from each national marine GIS committee will take part in a "regional marine GIS committee". While national committees will be responsible for national MSP work, the regional marine GIS committee will take overall responsibility for the practical MSP work for the whole RECOFI region. Countries having smaller EEZs may decide that it is not worth creating MSPs for their national area, but it would be essential for them to participate in the regional MSP work.

While work is planned towards a successful regional MSP, it would be advisable for Qatar to work on its own MSP as a pilot project, i.e. using a similar step-by-step approach as outlined above. Similar input data would need collecting for national work as for the regional work, and it would be important to liaise and arrange work with national representatives of other marine space sectors. In order to form an overall impression on what is required for this pilot project, Qatar should be consulting on any literature on MSP that it can access (especially Ehler and Douvere [2009] noted above). It would then be useful for Qatar to create maps showing potential MSP zoning for Qatari waters. From a functioning marine ecosystems perspective, Qatari marine waters are intricately linked with waters of their neighbouring States, i.e. with Bahrain, Saudi Arabia, the United Arab Emirates and Iran (Islamic Republic of), so it will be essential to secure marine spatial data from these countries in order that a more realistic zoning scenario can be developed. This would mean that the necessary data will need to be collected that could contribute to the mapping of the following marine zones:

- marine capture fisheries;
- mariculture;
- military zones;
- conservation zones (either biological, e.g. mangrove areas, coral reefs, or fishery conservation areas – no-take zones);
- energy extraction zones or points;
- ports, urban areas and holiday resorts (or other recreation areas);
- commercial shipping lanes;
- others?

Once the data have been collected and the above zones have been mapped, then the designation of fishery and mariculture zones can best be made. These zones might be variable, e.g. for different types of capture fishing, for mariculture, for certain named species, for vessels of different sizes, for seasonal use, etc. GIS could then be used to question the data or to establish any relationships between different activities, e.g. to answer questions such as "what proportion of the military zone could also be used for fishing purposes?" Once the basic work has been accomplished, initial attempts could be made to construct an MSP map for marine waters surrounding Qatar.

**Outcomes:** The necessary authoritative and legal structures should be put in place to allow for the creation of an MSP for Qatar as well as for other agreed national waters in the Qatari area. All major stakeholders (other marine sectors) should be identified and included, and a reliable zoning map should be produced.

**Proposed agency undertaking the work:** The lead to be taken by FAO in conjunction with senior government officials concerned with the marine environment, i.e. probably the Ministry of Environment and/or the Ministry of Municipality and Urban Planning.

**Estimated budget:**

| Phase | Tasks | Budget estimate (US$) |
|---|---|---|
| Phase 1 | Mobilization of project (pre-planning) | 19 000 |
| Phase 2 | Stakeholder dialogue and workshops | 21 000 |
| Phase 3 | Develop and approve the MSP | 53 000 |
| Phase 4 | Implementation strategy and planning | 32 000 |
| **Total** | | **125 000** |

*Note:* Excludes salary costs associated with existing government employees who would provide input to the project (e.g. GIS technicians) as these would be covered by existing running budgets within the Ministries.

**Time frame for implementation:** Between one and two years for the step-by-step process to be completed, although this depends upon continual progress being made. Most of the GIS-based zoning output could be completed at the same time.

**Proposed/potential funding sources**: Qatar Ministry of Environment (www.moe.gov.qa), National Food Security Programs e.g. Qatar National Food Security Programs (www.qnfsp.gov.qa), and Qatar National Research Fund (www.qnrf.org).

**Project title**: Provision of GIS training for personnel of RECOFI member countries as required

**Background:** From previous work carried out regarding the introduction of spatial planning for marine fisheries and aquaculture for RECOFI member countries, it is clear that there is a desire to utilize a range of spatial technologies as the optimum means of providing some of the necessary management capabilities. The main spatial technologies required are the use of GIS for data processing and analyses, plus familiarization with a range of associated technologies such as remote sensing and data logging equipment. Feedback obtained via previous RECOFI spatial planning workshops in Doha and Cairo, and from related questionnaire analyses, indicates that, if the planned spatial planning capabilities are to be introduced throughout RECOFI member countries, a variety of GIS training needs will have to be met. As well as providing practical GIS training *per se*, as a preliminary to training it will be essential for participants to first understand and become fully aware of: (i) the issues and needs for spatial planning; (ii) the core principles of EAA/EAF and MSP; and (iii) applications of relevance to spatial planning for problem solving and decision-making. The same feedback has also indicated that Qatar is the only Gulf State that is currently equipped to provide for the necessary GIS-related training. This concept note thus conveys the means by which training in the required GIS and related technology areas can best be met.

**Justification:** It has been established that marine capture fisheries in the Gulf are in a serious state of decline, and that this is the result of a combination of factors including overfishing, degradation of fish habitats, various sources of pollution, climate change and the competition for use of marine space in RECOFI waters. There is a large potential to increase marine capture fisheries productivity and to provide additional sources of high-quality fish protein from a range of mariculture activities. However, this revitalization of fisheries and the instigation of aquaculture production can only be accomplished by careful planning of the marine space. GIS has proved to be the ideal tool for spatial planning in a wide variety of fields including both aquaculture and fisheries.

Given that throughout the Gulf many thousands of artisanal fishers are highly dependent on the marine waters for their livelihoods, and as a source of employment and of high-quality food, then it makes

sense to try to reverse the deteriorating fisheries situation. This is particularly important in those coastal areas where additional sources of employment are virtually non-existent. In terms of a cost-benefit analysis, it is almost certain that the longer-term benefits to be gained by implementing GIS and its associated technologies will far outweigh any costs involved. The necessary GIS training required as part of this current project will also introduce to the RECOFI member countries a range of new and important technologies and skills that should prove to be of immense value in a world of rapidly changing needs and expectations.

**Objectives:** To ensure that each of the eight RECOFI member countries has a cohort of personnel who are able to carry out the required GIS work. This will mean that training in GIS and some associated technologies will be delivered. The personnel involved should have fisheries and/or aquaculture backgrounds. The numbers requiring training will vary according to the size of the country, the numbers of available personnel who already have sufficient skills, and the anticipated volume of work to be accomplished.

**Geographical area:** Qatar will provide the basic training for all RECOFI members. However, there is no reason why some of the training work (perhaps individual assignments) cannot be carried out in the home country of the trainees.

**Programme of work:**
(1) Preliminary considerations necessary for GIS training include:

- venue for training, including the facilities provided and the times available;
- suitability and availability of instructors;
- the hardware and software that are available and of most relevance/use to RECOFI member countries;
- readily available Qatari data and if possible data from other RECOFI member countries and RECOFI waters if they are also readily available;
- the exact range of courses that could be offered in terms of length and depth.

It is probably best to offer training at three levels: (i) a two-week course for candidates with little GIS experience that covers most of the basic requirements; (ii) a one-week course for persons with some GIS experience who need refreshing and/or perhaps in-depth knowledge on fishery/aquaculture applications; and (iii) a two-day course for better qualified people requiring specific training on certain aspects of the work. This latter course would probably involve more-or-less individual tuition and assignments.

(2) Contacting the other seven RECOFI countries suggesting the training possibilities. This would include:

- Attempt to find out their exact training needs. It is almost certainly best to insist that trainees have some knowledge of GIS or good computing skills plus some knowledge of fisheries or aquaculture.
- Explain the approximate nature of the work for each of the proposed courses.
- Try to ascertain the exact numbers requiring training and find out their preferred timings for the courses.
- Give details on all likely arrangements and costs involved.
- Identify the appropriate hardware and software to be used, i.e. the longer courses would include some elementary remote sensing work.
- Courses will mainly use readily available data from Qatar and, if available, data from other RECOFI member countries and RECOFI waters.

A request should be made for responses from each RECOFI country within a stated time.

(3) Preparing programmes of work. This will need to be done for each of the three courses as required, and this may include factors such as course venues, dates, documentation, presentations, demonstrations, data, and exercise assignments. The training itself would be very participatory (hands-on), with the aim for trainees to gain a good understanding of spatial planning for marine fisheries and aquaculture and the capabilities and limitations of the GIS tools for spatial planning. Written feedback on the background of each participant would need to be compiled to better design the course agenda, and all participants on the training programmes will need to be informed of course details.

(4) Run courses as required. This may require preliminary communications concerning travel arrangements, accommodation and other logistics. Ensure that trainees are adequately cared for during the duration of courses. Students should provide written feedback on the quality of the course, and at the conclusion of the course, lecturers should individually indicate the strengths and possible areas for improvements of each student. Make sure suitable literature is available, e.g. Meaden and Aguilar-Manjarrez (2013).

**Outcomes:** By the end of any of these courses, attendees should feel fairly confident that they know what to do in respect of spatial planning and operating a GIS, plus much of the language that accompanies this field, although this certainly does not mean that they will have a complete range of spatial technology skills. They should also know where to seek additional help, what type of GIS work is attainable, where various types of data might be obtained, what the limitations on any GIS output might be, and be able to have a feeling for whether their final output is credible or not.

**Proposed agency undertaking the work:** The Centre for GIS, in the Ministry for Municipality and Urban Planning has been identified (see Table 4b of the Questionnaire analysis).

**Estimated budget:** This will largely be determined by how many persons are in need of GIS training and at what level the training is given. It can be estimated that **costs per individual** might be according to the table below:

| **Type of course** | **Expense items (US$)** | | | | |
|---|---|---|---|---|---|
| | **Return travel to Qatar**[1] | **Accommodation, subsistence, internal travel** | **Tutor costs**[2] | **Extras, e.g. premises, manuals, overheads**[2] | **Total per attendee** |
| Two-week course | 500 | 3 300 | 3 900 | 720 | 8 420 |
| One-week course | 500 | 1 500 | 2 330 | 370 | 4 700 |
| Two-day course | 500 | 600 | 1 650 | 160 | 2 910 |
| **Total** | | | | | **16 030**[3] |

[1] Gives approximate mean cost for RECOFI region.

[2] Tutor costs and some of the extras are to be spread amongst the attendees –- for the purposes of this budget, it has been assumed that there would be 15 attendees and 2 tutors. Participants would use their own hardware (laptop computer).

[3] If all RECOFI countries were to send one person on each of the three proposed GIS training courses, there would be a cost of US$128 240 (i.e. 8 × 16 030).

**Time frame for implementation:** Courses should be completed within the first year of the implementation of the spatial planning project. It might be necessary to undertake additional courses as the spatial planning projects progress and as new staff join the project teams.

**Proposed funding source**: RECOFI member countries.

**Project title**: Identification of potential areas for marine aquaculture in RECOFI waters

**Background:** One of the recommendations from the technical workshop in Cairo was that there should be a concept note for a regional pilot project encompassing RECOFI waters areas for the identification of potential areas for marine aquaculture. As the Gulf is one waterbody divided into a number of national EEZs and territorial waters, there is a need for a regional project to identify the most suitable areas so that aquaculture development, from a regional viewpoint, can be carried out responsibly and sustainably.

**Justification:** The major common factor driving the growth of aquaculture in the region has been, and probably will continue to be, the need to increase the domestic food supply, partly because the wild fish catches may be unstable or decreasing, particularly for some commercial species. Although some RECOFI member countries have started, or are starting, aquaculture ventures, there is a need for a regional study to identify suitable locations for different types of aquaculture and to assess the scale of aquaculture development that could take place, i.e. to allow for the coordinated, responsible and sustainable development of marine aquaculture, thereby minimizing conflict with other sectors and users of the same water resource. The information from this project can supply an essential input to future MSP.

There is known potential for different types of aquaculture including net cage fish farming, onshore recirculation fish farming, onshore shrimp pond culture as well as mollusc and seaweed farming (Tables A1.1 and A1.2). The most suitable sites and zones need to be identified and carrying capacity estimates need to be calculated for those sites selected.

**Table A1.1**
**Fish species currently cultured in the Gulf**

| Scientific name | Common name | Local name |
|---|---|---|
| *Siganus canaliculatus* | Rabbit fish | Safi |
| *Epinephelus coioides* | Brown-spotted grouper | Hamoor |
| *Valamugil seheli* | Blue-spotted mullet | Biyah |
| *Sparidentex hasta* | Sobaity seabream | Sobaity |
| *Rhabdosargus sarba* | Gold-lined seabream | Gabit |
| *Sparus aurata* | Mediterranean seabream | |
| *Lates calcarifer* | Asian seabass or barramundi | |

**Table A1.2**
**Potential local species for culture in the Gulf**

| Scientific name | Common name | Local name |
|---|---|---|
| *Epinephelus coioides* | Brown-spotted grouper | Hamoor |
| *Scomberomorous commerson* | Kingfish | Kanaad |
| *Lethrinus nebulosus* | Spangled emperor | Shaari |
| *Pampus argenteus* | Silver pomfret | Zubaidy |
| *Diagramma pictum* | Painted sweetlip | Farsh |
| *Carangoides* spp. (4 species) | Trevally | Jesh |
| *Lethrinus lentjan* | Pink ear emperor | Shaari eshkheli |
| *Lutjanus ehrenbergii* | Ehrenberg's snapper | Naiser |
| *Euthynnus affinis* | Kawakawa | Sadah |
| *Siganus canaliculatus* | White-spotted spinefoot | Safi arabi |

**Objective:** To identify potential sites, culture species, types of aquaculture and scale of aquaculture activities in RECOFI waters, taking into consideration potential conflicts with other stakeholders and users of the coast and marine space.

**Geographical area**: RECOFI waters areas comprising RECOFI member countries' territorial waters and EEZs.

**Data required (at the Gulf scale)**:

- base map with coastline, topography and bathymetry;
- mean annual water temperature (seawater and marine groundwater);
- mean annual water salinity (seawater and marine groundwater);
- mean annual algal bloom concentrations;
- mean annual tidal fluctuations;
- meteorological data (wind direction, frequency and strength);
- major industrial discharge points;
- marine navigational channels;
- harbours;
- coastal building developments;
- marine habitat mapping (coral reefs, seagrass, mangroves, etc.);
- marine protected areas;
- other marine and coastal areas having special designations.

**Data sources:** ministries/directorates of fisheries, aquaculture and marine resources; environmental ministries/directorates; directorate of planning, survey and land registration; aquaculture and marine research institutes, universities; satellite image analyses, etc.

**Methods**:

(i) Identify site selection criteria for fish cages and pens, mollusc and seaweed longlines as well as for coastal pond culture and recirculation tank farms.
(ii) Identify data sources, collect data from data sources, input data into GIS.
(iii) Identify gaps in data; seek these data or collect field data.
(iv) Download free satellite images readily available on the Internet, analyse satellite images for potential coastal sites and sea areas.
(v) Undertake simple/general satellite image analysis of coastal areas away from sensitive habitats, industrial/domestic development, wadis, etc.
(vi) Determine:
    a. coastal site selection criteria for recirculation farms, hatcheries and tank and pond farms;
    b. off-the-coast site selection criteria for marine fish cage and pen culture, mollusc and seaweed culture.
(vii) Using GIS, prepare layered maps of the data to:
    a. identify exclusion zones;
    b. identify sensitive and conflict zones with buffers;
    c. identify potential aquaculture zones.
(viii) Map other coastal and marine users, identify potential areas with low conflict.
(ix) Prepare an aquaculture atlas of potential sites.
(x) Undertake carrying capacity estimates in the selected zones using broad carrying capacity estimates based on tonnes per kilometre of coastline or tonnes per square kilometre.

**Outputs or outcomes**:

- A marine aquaculture atlas for RECOFI waters, illustrating sites with potential for aquaculture with recommended culture systems and initial estimates of carrying capacity.

**Expected benefits:**

- Estimated location and scope of potential aquaculture for national agencies responsible for aquaculture development and planning.
- Coordinated aquaculture development plan for RECOFI waters.
- Suitable aquaculture sites for potential investors, thus sourcing additional rural employment and incomes.
- Inputs for the development of a regional marine spatial plan.

**Proposed agency undertaking the project**: FAO and/or other specialized company.

**Estimated budget**

| Budget item | Details | Costs (US$) |
|---|---|---|
| Staff | 1 staff full time for 6 months | 25 000 |
| Data purchases | Spatial data (e.g. environmental, socio-economic, etc.) | 40 000 |
| Analysis | 1 person full time for 6 months | 25 000 |
| Expenses | GIS-related software and ecological carrying capacity models | 20 000 |
| Other | Atlas preparation and printing | 20 000 |
| **Total** | | **130 000** |

**Time frame for implementation**: Two years.

**Proposed funding source**: RECOFI member countries.

## NATIONAL SPATIAL PLANNING PROJECTS

### Marine capture fisheries projects

This synopsis of the marine fisheries pilot projects is divided into three main sections as follows:

1. The initial proposals made for pilot projects.
2. Three suggested marine fisheries pilot projects
3. RECOFI countries' detailed pilot projects

### 1. The initial proposals made for pilot projects

An intended output from the Cairo workshop was that each RECOFI member country should produce proposals for both a GIS-based pilot project designed to address an aquaculture problem/issue and a similar project relating to marine capture fisheries. This section of the report concentrates on the marine capture fisheries pilot projects. The submitted titles for marine capture fisheries proposed projects were as follows:

| | |
|---|---|
| • Bahrain | Fishing effort distribution in the EEZ of Bahrain |
| • Iran (Islamic Republic of) | No project was submitted |
| • Iraq | Identification of protected habitats for some commercially important species in the EEZ of Iraq |
| • Kuwait | No project was submitted |
| • Oman | Identify the cause of kingfish decline in the EEZ of Oman |
| • Qatar | Identification of nursery grounds for demersal species in the western waters of Qatar |
| • Saudi Arabia | Mapping the fishing effort of shrimp fishery in the Al Qatir area |
| • United Arab Emirates | Identification of spawning habitat of demersal species in EEZ of the United Arab Emirates |

Although all of these proposals could provide valid GIS-based studies, in practice this would not always be possible. This is either because the proposed projects require sophisticated spatial modelling approaches (which would only be expected of highly trained GIS workers), or because projects require spatially referenced data that the countries do not have access to and that may require considerable time or expense in its collection.

Because of these difficulties, the RECOFI countries' pilot projects have effectively been placed into four categories as follows:

(i) Countries that can proceed with their suggested projects: Bahrain, Qatar and Saudi Arabia. For these countries, guidance details of their pilot projects have been set out below.

(ii) Countries whose suggested pilot projects are too complex: Oman and the United Arab Emirates. For these countries, the complexity of their proposed project will be briefly explained, and it is suggested that they undertake one of the three less-difficult projects (see following section).

(iii) Countries that have not submitted a pilot project proposal: Iran (Islamic Republic of Iran) and Kuwait. It would be feasible for one or both of these countries to work together with Iraq and to undertake the study suggested by Iraq. Alternatively, both of these countries would be advised to undertake one of the three suggested projects (see following section).

(iv) Country whose suggested pilot project is not appropriate to their marine spatial area: Iraq. In the case of this country, it is considered that, although the project is theoretically attainable, the extremely small EEZ of that country means that any output from the pilot project might be either highly unreliable or very generalized. The suggested project would best be carried out in conjunction with one or both of its neighbours, i.e. Kuwait and Iran (Islamic Republic of). If

that proves to be difficult to organize, then Iraq should also attempt one of the three suggested pilot projects described below.

**2. Three suggested marine fisheries pilot projects**

These are three GIS-based projects that are recommended if the RECOFI countries' projects are too difficult or are inappropriate:

**Resource distribution mapping**
As the basis for most future GIS work, it will be essential that data distribution maps can be produced, i.e. to show the distributions of any marine-related resources. These maps are certain to be essential for any future fisheries GIS work that will be undertaken. The mapping of resources will be limited to those for which the country has spatial data. It is suggested that possible starting digital maps could be produced showing the following:

- the coastline and EEZ of the country and its territorial waters;
- depth (bathymetry) within the territorial waters;
- water temperatures – by season or month (use surface water temperature, salinity, and dissolved oxygen data from satellite imagery);
- bottom sediment types;
- marine habitat areas (mangroves, coral reef, seagrass beds, etc.);
- areas prohibited for fishing (military areas, main shipping lanes, conservation areas, etc.).

Once all or some of these distribution maps have been successfully produced, practise overlaying pairs of maps. For example, a map showing "water depth" could be overlaid with a map showing "bottom sediment types", and then a new map could be produced showing, for example, all areas more than 50 m deep and with sandy sediments. This type of mapping could be attempted for any pair of variables, and data could be obtained to show, for example, how many square kilometres of the country's EEZ (territorial waters) were comprised of waters deeper than 50 m having sandy sediments.

**Estimated budget for project**

| Budget item | Details | Costs (US$) |
|---|---|---|
| Hardware and software | Computer, UPS, printer, scanner, notepad or tablet, GIS software. | 6 000 |
| Data | Purchase of some of the data | 5 000 |
| Data collection expenses | Travel and subsistence | 3 000 |
| GIS operating and analysis | One person part time for one year | 10 000 |
| **Total** | | **24 000** |

**Fishing effort deployment**
If data have been collected on fishing effort deployment, which is in some way georeferenced, then these data can be represented and mapped in various ways. They can be mapped by season, month, target species, boat type, fishing method, etc. Once fishing effort were mapped, it would be possible to derive statistics from the GIS on factors such as:

- average distance from the shore of each fishing method or fishing boat type;
- total effort deployed at various distances from the coast;
- total fishing effort deployed in various grid cells;
- differences in fishing effort between boats coming from different ports;
- differences in seasonality and fishing methods used.

If the data do not exist, then it would be quite easy to collect them by doing questionnaire surveys at a good sample of different fishing locations (harbours, ports, villages, etc.). For this, it would be necessary to interview as many fishers as possible, asking how much fishing effort they had put in

over the previous six months (or a shorter period) in each zone on a map. Thus, it would require a map of the country's territorial waters (EEZ) that divided the marine area into cells of, say, 5 km × 5 km, and each fisher would report (approximately) how many days (or hours) they had spent fishing in each cell. All fishers' answers would need to be aggregated for every cell to calculate a sample of the total effort applied. GIS tools and functionalities would do the aggregation and then provide mapping output to show this. Effort could also be calculated in terms of person hours. So, if there were three people in a boat, this could be three times as much effort compared with there being one person in the boat. There are many other ways of measuring fishing effort.

**Estimated budget for project**

| Budget item | Details | Costs (US$) |
|---|---|---|
| GIS hardware and software | Computer, UPS, printer, scanner, notepad or tablet, GIS software. | 6 000 |
| Data collection staffing | Staff – 2 part time for one year | 12 000 |
| Questionnaire compilation, data entry and analyses | Staff – 1 person part time for one year | 10 000 |
| Data collection expenses | Travel and subsistence | 6 000 |
| **Total** | | **34 000** |

**Marine activities carried out within the EEZ**

As a prelude to MSP, it would be useful to create maps showing potential MSP zoning. This would probably mean that the necessary data will need to be collected, but this should not be too difficult. Careful thought on the best way to map these data would need to be given. It is suggested that marine zones could include:

- military zones;
- conservation zones (either biological, e.g. mangrove areas, coral reefs, or fishery conservation areas – no-take zones);
- energy extraction zones or points;
- ports, urban areas and holiday resorts (recreation areas);
- commercial shipping lanes;
- others?

Once the data have been collected and mapped, any relationships between these activities could be mapped, and then used to answer to questions such as "what proportion of the military zone is also used for fishing purposes?" or a tentative attempt could be made to construct an MSP map for the country's EEZ.

**Estimated budget for project**

| Budget item | Details | Costs (US$) |
|---|---|---|
| GIS hardware and software | Computer, UPS, printer, scanner, notepad or tablet, GIS software. | 6 000 |
| Data | Purchase of some of the data | 5 000 |
| Data collection expenses | Travel and subsistence | 3 000 |
| GIS operating and analysis | One person part time for one year | 10 000 |
| **Total** | | **24 000** |

The budget estimates shown in these three potential pilot projects assume that most data are already available (except those that need collecting via questionnaire). Experience shows that some data may have to be purchased. It also considers that hardware and software will be used after the pilot projects and that a write-off period for this may be four years. Moreover, the costs are considered to be similar for each RECOFI country.

## 3. RECOFI countries' detailed pilot project

Where possible, the same subheadings have been used in order to outline each country's pilot project proposal. However, because of the problems noted in section 1 above, these subheadings cannot be incorporated in all of the proposals, and suitable modifications have been made (including changes to some project titles). Project subheadings are: project title; background; justification; objectives; geographical area; data required; data sources; methods; output or outcomes; beneficiaries; proposed agency undertaking the project; and estimated budget.

### Bahrain

**Project title:** Fishing effort distribution in the EEZ of the Kingdom of Bahrain

**Background:** Relative to other countries, Bahrain has a small EEZ measuring some 3 800 $km^2$ and a coastline of only 590 km. Bahrain's population is about 1 million. Due to its geographic location, with the country being < 25 km from the territorial waters of both Saudi Arabia and Qatar, any major fish stocks are certain to share these territorial waters. Most fishing is carried out by artisanal fishers using mainly small fibreglass boats. Only 6 percent of boats are longer than 11 m. A wide range of fishing gear is deployed, e.g. 326 artisanal vessels use shrimp trawls, 250 vessels deploy wooden-framed gillnets, and 793 vessels use wooden gargour traps. Before 1998, there were a number of large steel-hulled trawlers operating, but they were banned when they came into conflict with small-scale fishers.

In recent decades, fishing effort has risen, and production peaked in 1996 when the total catch was almost 13 000 tonnes. More recently, there has been a marked decline in total fish catches, and the country now relies on imports to fill the fish demand gap. A range of tropical species, e.g. mainly rabbit fish, emperors and groupers, were originally caught but overfishing has led to stock collapses, e.g. orange spotted grouper catches declined from 811 tonnes in 2003 to 176 tonnes in 2009. A situation now exists whereby the only sizeable stocks are of crab and shrimp, plus limited amounts of finfish. There are also significant environmental problems in the inshore marine waters. Since 1985, 99 percent of the former coral reefs have died, largely owing to climate change (with very high summer water temperatures) and to inappropriate human activities. Environmental problems have also been caused by sea-to-land reclamation projects (an estimated 88.5 $km^2$ of land was reclaimed between 1964 and 2007, mainly adjacent to the northeast coast), and through dredging large quantities of sand from coastal waters. There has long been a ban on shrimping from March to July, and although attempts at lengthening this ban period have been discussed, it would be hard to enforce because it would be very unpopular with the many artisanal fishers.

**Justification:** As fishing is the source of employment for about 10 000 mainly poorer, rural workers, there is now an urgent need to revitalize all fisheries. Other major fishery associated needs include:

- To ascertain the efforts put into various modes of fishing. Recent modelling indicates that there is a large oversupply of fishing effort, and with almost no controls on monitoring effort plus limited compliance with regulations, it means that large-scale illegal fishing readily occurs.
- To set up MPAs. Bahrain's small EEZ should make the necessary data acquisition for delimiting MPAs a relatively easy task.
- To revitalize coral reefs. A commercial pilot project is under way to locate artificial reefs in various areas in an effort to replace destroyed natural reef areas (see http://websrv.municipality.gov.bh/mun/docs/MunicipalConference2012/Day2_26thApril/papers/34.%20Michael%20Arrora.pdf). This work will need to be significantly extended.
- To restock inshore marine areas. Some attempts have been made at restocking shallow marine waters, but the efficacy of these attempts is currently almost impossible to measure.

- To discontinue coastal degradation activities. The large-scale dredging and reclamation schemes urgently need to be stopped or at least minimized, especially in those areas that retain high-quality inshore ecosystems.
- To perform zoning in Bahrain's EEZ. The need to carry out MSP in conjunction with neighbouring countries will be essential if marine activities are to be both sustainable and revitalized.

As all of the above fishery needs have a strong spatial component, the application of GIS-based techniques will be very helpful.

**Objective:** As there is an assumption that overfishing has been taking place in Bahrain waters, it will be essential to obtain objective data on this in terms of both how much fishing is really occurring, and where this fishing is taking place. Given availability of the right data, this project could be further refined so as to indicate effort and fishing locations in terms of different fishing gear types used, and in terms of the seasonality of fishing. In addition, there should be a consideration of whether there was a wish to integrate any fish catch data into this study. Any data gained from this project could also form the basis for further projects to ascertain relationships between fishing effort and, for example, water depth, distance from home ports, sea-bottom sediment type, etc. An analysis over a full year is seen as practicable.

**Geographical area:** All 3 800 $km^2$ of the EEZ of Bahrain.

**Data required:**

- Base map (or maps) of the coastline of Bahrain and the EEZ subdivided into cells. A crude resolution would be 10 × 10 km cells (but this would only give 38 cells for the entire EEZ). Better to use 5 × 5 km cells, which would produce about 152 cells.
- Some indication of fishing effort inputs into each cell. This might be by mean boat hours, mean person hours per week, mean kilometres trawled per week, mean number of traps/pots set per week, port/place of origin of fishers, etc.
- As the above data might need to be collected via questionnaire/interviews, it could be worth acquiring data about species caught (quantity and cell location) at the same time.
- If further GIS-based analyses are required, then data on factors such as marine bottom type, bathymetry and water temperatures might need to be acquired.

**Data sources:**

- According to information given in the questionnaire (completed for this workshop – Table 3a): "The fisheries department is collecting monthly fish landings data regarding fishing gear/boat, fishing efforts per landing site and other fisheries statistics." The exact nature of these data, plus their coverage, should be investigated to see how useful they might be for the pilot project.
- The MarGIS project should be consulted in terms of what data are held (see http://unesdoc.unesco.org/images/0013/001356/135689e.pdf), although these data might not be up-to-date.
- Explore the recent, high-quality marine digital data held by PH Environment Gulf (http://websrv.municipality.gov.bh/mun/docs/MunicipalConference2012/Day2_26thApril/34.%20Michael%20Arora.pdf). It appears to have digital data sets for many marine variables for most of the Bahrain EEZ.
- If the data mentioned in the first bullet above are unsatisfactory, the required data should be gained by interviews with fishers at all major ports. This project could only be based on sample surveys, but it would be important to gather the data at sufficient times, frequencies and locations so that valid information can be obtained.
- Topographic mapping data to show all of Bahrain's coastline and EEZ can be obtained from government mapping sources.

**Methods:**

(i) Produce a base map for the EEZ of Bahrain showing the coastline, main settlements or features and the location of the marine area cells (either 5 × 5 km or 10 × 10 km).
(ii) Explore the data sources (above) and their availability. If not appropriate, then move to point (iii) below.
(iii) Work out a timetable for fishing site visits that enable fully representative data to be collected.
(iv) Devise a relevant questionnaire and data collecting sheet. Consider the use of a notepad computer with pre-formed data sheets on which the data can be collected. Otherwise, collect data using manual methods (pen and paper).
(v) Collect data (at times and seasons that will give the most realistic results). The data to be collected is described under "Data required" above.
(vi) Enter data into database.
(vii) Perform GIS functions that satisfactorily map the data collected. The data will be presented in terms of "fishing effort per grid cell".
(viii) Carry out any further analyses required.

**Output or outcomes:** Maps showing an estimation of the amount of fishing effort per grid cell in Bahrain marine waters, e.g. by category of vessel, type of gear used, by port of origin of boat, by season of fishing, depth of water. The information from the data could also be produced in tabular form.

**Beneficiaries:** Fishery managers, the Directorate of Fisheries and Marine Resources, and eventually the fishers themselves through the application of better-informed decision-making.

**Proposed agency undertaking the project:** Directorate of Fisheries and Marine Resources.

**Estimated budget**: Project costs are estimated as per the following table. This assumes that all effort-related data (excepting the basic coastline data) must be collected via field surveys, and that any additional analyses deployed would use freely obtainable digital data from local sources. There is also an assumption that hardware and software would be purchased specifically for the pilot project, and it could then be used for subsequent GIS work:

| Budget item | Details | Costs (US$) |
|---|---|---|
| GIS hardware and software | Computer, UPS, printer, scanner, notepad or tablet, GIS software. | 6 000 |
| Data collection staffing | Staff – 2 part time for one year | 12 000 |
| Questionnaire compilation, data entry and analyses | Staff – 1 person part time for one year | 8 000 |
| Data collection expenses | Travel and subsistence | 6 000 |
| **Total** | | **32 000** |

**Iran (Islamic Republic of)**[2]

**Project title:** Not available.

**Background:** Fisheries activities in Iran (Islamic Republic of) are concentrated in three regions: (i) southern fishery (the Gulf and the Gulf of Oman); (ii) northern fishery (Caspian Sea); and (iii) inland fishery and aquaculture. In 2003, these three regions produced 299 000 tonnes, 32 000 tonnes and 110 000 tonnes of catches, respectively. The country shares fisheries resources in the Gulf, and an absence of a recognition of an EEZ in this area has resulted in frequent conflicts, in contrast to the Gulf of Oman, where there are no conflicts. The industrial fleet includes purse seiners targeting large pelagic species, trawlers for shrimp, and other vessels for demersal resources and for mid-water trawls of pelagic species. The artisanal sector includes activities performed by pair-boat purse seiners, dhows, skiffs and other fisheries that do not need fishing vessels, e.g. such as beach seine or barrier net fisheries. Expansion of deep-sea fishing since 1998 increased this sector's share of tuna catches from 5 percent in 1995 to more than 12 percent in 2003. Principal fisheries in the Gulf include silver pomfret and demersal species. The Iranian Fisheries Research Organization (IFRO), a state-owned company, is responsible for fisheries development.

As with other RECOFI members, catches of all species in Gulf waters have declined significantly in the past two decades, and Iran (Islamic Republic of) has thus given far more attention to fisheries in the Indian Ocean. Fisheries contributed only 0.23 percent of the national economy in 2003, and fish are not a popular consumption item in non-coastal Iranian cities, where meat is preferred. This results in a per capita consumption of fish of only 5.3 kg/year. The Government recognizes the need to reduce fishing effort in the southern fishing grounds, and it is now trying to cap this effort. Further useful background information can be obtained from ftp://ftp.fisheries.ubc.ca/CodeConduct/CountriesCodePDF/Iran-CCRF.pdf, and this document contains a large amount of detailed and pertinent information concerning fisheries management needs in the country from both a direct management perspective as well as from social and environmental viewpoints. Additional factual data on all aspects of Iranian fisheries are available at www.fao.org/fishery/countrysector/FI-CP_IR/en.

**Justification:** Iran (Islamic Republic of) has already implemented a web-based Fisheries/Marine Information System (FMIS), and a completely new Information System (IS) for managing aquaculture and fisheries is now being developed (see Table 3a of the 2012 questionnaire). These information systems can act as reservoirs for suitable marine and fisheries data. The Government recognizes the need for enhanced management of its fisheries and has put into place many measures to address this, e.g. there is a vessel buy-back scheme, enlightened management schemes among artisanal fishers have been introduced, sustainability concepts have been introduced, and there are improved data collection measures (with VMS and other GPS data collection facilities being now installed on many larger vessels). In addition, new laws now prohibit:

- fishing without permission;
- fishing during bans (season-wise, species-wise and area-wise);
- holding or usage of unauthorized fishing nets, dynamite, etc.;
- releasing wastes and oil pollutants into the sea.

[2] Iran (Islamic Republic of) did not send a representative to the RECOFI Cairo workshop, and thus a pilot project was not submitted. Despite several requests, a pilot project has not been forthcoming. It is therefore recommended that Iran (Islamic Republic of Iran) carry out one of the suggested projects detailed in Annex 1 above, pp. 96–97, or that it works in conjunction with Iraq (and perhaps Kuwait) on the GIS-based pilot project that Iraq has suggested. This also means that most of this information on the project proposal cannot be completed.

There are also management plans to restore depleted stocks, i.e. through "sea ranching" of shrimp, greatly restricting the shrimp fishery season, and the establishment of MPAs. Given the recognition that there are many problems facing the Gulf fisheries, that progress is being implemented in enhanced management, yet there is a need to control fisheries in the light of fairly substantial planned increases in fish catches, then the justification and need for spatial planning tools is really quite urgent.

**Estimated budget:** If Iran (Islamic Republic of) chooses to undertake one of the suggested pilot projects outlined in Annex 1 above, pp. 96–97, the likely costs will be in the region of those outlined for the proposed/suggested projects shown (i.e. about US$24 000–34 000). If the decision is made to undertake a joint project with Iraq, new budget figures would have to be estimated.

**Iraq**[3]

**Project title:** Identification of habitats in need of protection for some commercially important species in the EEZ of Iraq.

**Background:** The marine EEZ of Iraq covers an extremely limited area at the southern extremity of the country (or the northwest extremity of the Gulf) The only direct contact of the coastline with marine waters of the Gulf lies between the Khor Abdullah estuary in the west and the Shatt al Arab waterway in the east, a distance of about 60 km. Given this very limited access to territorial waters, production has always been small. Since the 1990–91 Gulf War, this production has in fact declined and, although data on production are scarce, it is likely to total about 5 000 tonnes per year. Some sources state that all fishing is of an artisanal kind, with fishing methods including gill, cast and trap nets, plus some trawling from traditional dhows, but it is likely that some 20 m trawlers exist that fish at considerable distances from Iraq's EEZ. The number of small artisanal vessels is about 400. The main species landed are shad, pomfret and mullet.

In the 1990s, the fisheries were severely depleted because sources of freshwater in the south were cut off, causing massive environmental disturbance to the spawning ecosystems. Although attempts are being made to redress, this problem they are hampered by a severe depletion of freshwaters in the Tigris and Euphrates catchments, where freshwater is being extensively extracted. In this rather remote area, fisheries management is extremely week and thus unregulated, e.g. it is likely that the international borders are regularly transgressed, with some Iraqi fishing taking place across the northern Gulf waters.

**Justification:** Because Iraq's marine fisheries are small and the stocks upon which it relies are shared with other countries of the region, regional cooperation in fisheries management is essential for Iraq, as well as for other countries in the region. Thus, any future fisheries GIS work will probably have to be carried out in conjunction with at least one neighbouring country, most probably with Kuwait for reasons associated with language. Spatial analyses will be important in the sense that the environmental stresses are severe in this area and they have been drastic changes. Gulf waters here are liable to extremes of temperature and salinity, and the decreases in freshwater availability are likely to

[3] There are a number of problems with respect to this suggested project:

- Iraq has almost no marine space and only a very small marine fishery.
- It appears to have no marine data.
- It would make sense for Iraq to undertake a marine project in cooperation with one or both of its neighbours (Kuwait and Iran [Islamic Republic of]).
- Neither Kuwait nor Iran (Islamic Republic of) has submitted pilot marine fisheries projects.
- The suggested project itself ought to be carried out in the sense that results from it would be urgently needed, but to do it successfully would require many data and perhaps some sophisticated modelling techniques (depending on the methods used).

A start has been made on this project synopsis, but it cannot realistically be completed without discussions between (or with) Iraq and its neighbours, in the hope of establishing a working mandate.

be causing rapid environmental and biodiversity implications and change. In addition, aquatic environments are likely to be quite diverse in the sense of the existence of brackish waters giving highly variable physiological conditions. There are no inventories of marine fishery resources in Iraq.

**Objectives:** The title of this pilot project is being interpreted as "Identification of habitats in need of protection for some commercially important species in the EEZ of Iraq". It should be mentioned again that this project should be undertaken in conjunction with the fishery authorities in Kuwait and perhaps in Iran (Islamic Republic of) – these might be either national or local authorities. The reason for this is that it is impossible to think that Iraqi waters (or aquatic environments) would be providing protected habitat only for fish that inhabit its own territorial space. The objectives would be to identify habitats that are in need of protection because of the refuge that they are offering to species during one or more of their life stages.

**Geographical area:** As noted above, the geographical area should best intrude into both Kuwait and Iranian waters. Ideally, this area might stretch right across the northern Gulf shoreline, although this extent would depend on data limitations, and it would need to be the subject of negotiation.

**Data required:** First, the species to be studied need selecting with care. Thus, it would make sense to either select species about which much is known (or for which some data are available), or species of commercial importance. A major problem for this project is likely to be that insufficient data are available. Thus, data needed should be:

- digital outlines of the coastline including islands and estuaries;
- bathymetry data for the area;
- salinity data (seasonally);
- temperature data (seasonally);
- bottom sediment types;
- any distinctive habitat classes, e.g. mangroves, seagrass beds, coral reef, intertidal mud flats, etc.;
- data on species distributions, especially during spawning times, or of nursery areas.

If adequate data are not held, then for species protection purposes, it might be sufficient to simply map known locations where individual species are seen to congregate. Having done this, it might be possible to assess the characteristics of these locations, and thus to try to establish if there are commonalities about certain areas.

**Data sources:** According to recent questionnaire analyses, there are no existing data for fisheries GIS purposes in Iraq, and even for Kuwaiti waters they are likely to be scarce.

**Proposed agency undertaking the project:** Perhaps the Ministry of Agriculture or the General Board for Fish Resource Development (though this board seems to be concerned with inland fisheries only), or the Fish Department at the university in Basrah (not listed in the University of Basrah prospectus. (These organizations were suggested in a 2010 questionnaire survey.)

**Estimated budget:** It is impractical to state an estimated budget because this would depend very much on whether Iraq chooses to do one of the suggested projects (i.e. about US$24 000–34 000, in Annex 1 above, pp. 96–97) or whether Iraq pursues its suggested project with one or both of its neighbours.

**Kuwait**[4]

**Project title:** Not available.

**Background:** As in most other RECOFI countries, marine fishing is dominated by smaller artisanal craft, i.e. skiffs, dhows and small trawlers, with there being about 900 of these vessels. However, Kuwait also has about 30 steel-hulled trawlers that undoubtedly fish beyond the country's EEZ. All vessels are owned by Kuwait although they are mostly crewed by migrant workers. Fishing is only allowed at distances of > 3 nautical miles from the coast. The industry is further regulated by the fact that no new fishing licences have been given since 1988, and to obtain a licence for a large boat, two licences for small boats must be forfeited. Recent fish catch statistics indicate that Kuwait probably has the lowest total marine catch rates of any RECOFI country (4 373 tonnes were landed in 2007), although other sources give this position to Iraq. Catches are dominated by shrimp plus a small variety of finfish species.

**Justification:** According to the Kuwait Institute for Scientific Research (www.kisr.edu.kw/Default.aspx?pageId=522) fishery surveys on a broad range of subjects have been carried out for 30 years, hence the data collected could be useful for any GIS work. Although a number of measures have been taken towards achieving sustainable fisheries, e.g. restrictions on inshore fishing, a closed season for shrimp fishing, restrictions on new fishing licences, rules regarding fish net size, plus the fact that Kuwait has signed up to a number of UN fishing agreements (see www.un.org/depts/los/general_assembly/contributions_fisheries/2012/Kuwait.pdf), the situation regarding stocks of most species is still very poor. Indeed, a news report dated July 2011 (see www.thenational.ae/news/world/middle-east/over-fishing-forces-kuwait-to-consider-two-year-ban) noted that Kuwait was considering complete closure of all fisheries for two years. The report also noted that prices for finfish increased by a factor of three in the period 2007–2011, and that fish catches in 2011 were about 20 times less than they were in the early 1990s.

According to another recent study (see www.macrothink.org/journal/index.php/ast/article/view/2778), the ratio of bycatch to shrimp catches in 2011 in the Kuwaiti fishery varied from 5.4 at the beginning of the season to 73.6 at the end of the season. In that season, 15 704 tonnes of bycatch was discarded – this represents 86 percent of all bycatch caught in the shrimp fishery and it is almost four times the total of all retained fish catches. Along with these fisheries statistics, the FAO Fisheries and Aquaculture Report No. 961 (p. 6) lists a large number of human-induced pressures that are exacerbating an already poor situation. There is a very clear need to enhance Kuwaiti fisheries and marine management. On the positive side, and although Kuwait has made little progress in implementing any fisheries GIS work, according to an answer in section 6 of the 2010 GIS questionnaire (see FAO Fisheries and Aquaculture Report [2011; Table 6A], there appear to be a number of organizations that might cooperate with the fishery authorities in taking forward the marine/fisheries GIS work.

**Estimated budget:** If Kuwait chooses to undertake one of the suggested pilot projects outlined in Annex 1 above, pp. 96–97, the likely costs will be in the region of those outlined for the proposed/suggested projects shown (i.e. about US$24 000–34 000). If the decision is made to undertake a joint project with Iraq, new budget figures would have to be estimated.

[4] Kuwait did not send a representative to the RECOFI Cairo workshop, and thus a proposed pilot project was not provided. Despite several requests, a pilot project has not been forthcoming. It will therefore be recommended that Kuwait carry out one of the suggested projects detailed in Annex 1 above, or that it works in conjunction with Iraq (and perhaps Iran [Islamic Republic of]) on the GIS-based pilot project that Iraq has suggested. This also means that most of this information on the project proposal cannot be completed.

**Oman**[5]

**Project title:** Identify the cause of kingfish decline in the EEZ of Oman.

**Background:** The 2 810 km of the Omani marine coastline can be subdivided into three areas: (i) the Gulf, (ii) the Gulf of Oman, and (iii) the Arabian Sea. The Arabian Sea area especially benefits from an intense upwelling that brings nutrients to the surface, and these form the basis of a prolific fishery. In 2006, Oman had the second-largest production of fish for all RECOFI countries, at about 150 000 tonnes, and annual per capita consumption of fish is very high at about 28 kg. Some 87 percent of fish production is from artisanal fishers, and 13 percent comes from the industrial sector. The industrial fleet of about 30 vessels comprises longliners and trawlers targeting yellowfin tuna and demersal resources, respectively, in the Arabian Sea. However, the Omani trawler fishery that operated in the Arabian Sea was closed by government decree in 2011. Oman's artisanal fleet of more than 13 000 vessels is composed of dhows and skiffs (small motorized craft), and it fishes in all of Oman's marine waters. Diving collection is also undertaken in the abalone fishery. Dhows use wire fish traps, troll/handlines, purse seines and nets. Skiffs use lobster traps, cast nets, wire fish traps, troll/handlines, nets and more; they also support beach seine activities. Skiffs with cast nets and lobster traps fish exclusively in the Arabian Sea.

**Estimated budget:** Because of the problems outlined in footnote, [5] this is likely to be in the range of the costs outlined for the proposed/suggested projects shown in Annex 1 above (i.e. about US$ 24 000–34 000).

**Qatar**

**Project title:** Identification of nursery grounds for demersal species in the western waters of Qatar

**Background:** Qatar has a total coastline of 563 km and its EEZ (35 000 $km^2$) is heavily influenced by adjacency to Saudi Arabia, Bahrain the United Arab Emirates. Its coastal waters are extremely shallow, averaging 30 m along the northern and eastern coastlines, and only 20 m along the western coastline. Bottom sediments are mainly compacted sands or sand and mud, although areas of seagrass and corals are quite extensive. Similar to most of the Gulf, water temperatures and salinity readings are very high. Qatar has about 500 artisanal fishing vessels with about 50 percent being fairly large, i.e. > 16 m, and the fishery directly employs almost 5 000 people. Total fish production from the Qatari fleet was about 16 000 tonnes in 2007, and the country is largely self-sufficient in terms of fish needs. Most fishing is carried out within six miles of the shore, and methods used include gillnets, driftnets, handlines, and wire fish traps. Trawling is not allowed in the country, and shrimp trawling has been banned since 1991. The main species caught are mixed pelagics, plus emperors, seabream and groupers, and a range of crab species. Most fish caught are consumed within the country, and almost 50 percent of the catch passes through the main Doha fish market. Fisheries enforcement is a major problem and a large amount of illegal fishing takes place. The fishery generally would be classified as "mature" with there

[5] Without more detailed information, it is not possible to complete this concept note. It would be a difficult project to do using GIS because there could be so many causes of kingfish decline. Moreover, there are no good indications of what data sources are available for the whole country, and it appears from questionnaire answers that mainly localized data may be available based on certain local projects. Another major obstacle for a pilot project such as this is that, in order to monitor species decline, it would be necessary to have longer-term temporal data, which almost certainly would not exist. Oman has not been informed of these project deficiencies because the Omani representative at the Cairo workshop might not have been familiar with the requirements of working in a GIS environment. This pilot project was not one of those suggested by Oman in the recently completed RECOFI spatial planning questionnaire. Because of these problems, most of the subsections of this proposal have not been completed, and it is recommended that Oman complete one of the three suggested GIS marine fisheries projects as outlined in section 2 above.

being almost no prospects of increased catches or effort until much environmental remediation has occurred together with more effective and efficient management.

**Justification:** As with several other RECOFI countries, the justification for enhanced spatial planning for marine (including coastal) areas is very high indeed. The reasons for this include:

- severe habitat degradation, particularly of mangroves, coral reefs, intertidal mud flats, seagrass areas and a range of inshore potential fish spawning environments;
- the overexploitation of fish stocks;
- the inherent environmental difficulties caused by the extreme environmental conditions;
- the lack of environmental awareness among most of the population;
- pollution causing high mortality and diminished reproduction among many species – pollutants include industrial effluents, oil, sewage discharges, chlorinated cooling waters, and ship ballasts;
- the need for regional cooperation in areas having several adjoining EEZs;
- the important need to understand the extent to which stocks are shared with neighbouring countries;
- the need to identify and select MPAs and to establish the geography of the life stages of all the main commercial species;
- the need to incorporate EAF and MSP considerations into all future fishery and marine policies.

**Objectives:** To utilize GIS capability in order to ascertain nursery habitats for selected demersal species. The species have not been mentioned, and this would be an important decision. This project could be carried out at a number of "levels of sophistication". The accompanying box contains a brief account of some of these methods. From these, it should be noted that the habitat modelling techniques are quite complex, and they should be avoided until more GIS or modelling confidence/expertise has been acquired.

**Selected references showing how fish nursery grounds may be established**

The Florida Fish and Wildlife Commission uses a method of locating spawning or nursery grounds that relies on habitat modelling techniques (see http://myfwc.com/research/saltwater/fish/spotted-seatrout/mapping/).

The Identification of the Spawning Areas in the Dover Strait (ISADO) project (see www.canterbury.ac.uk/News/newsRelease.asp?newspk=754) generally describes some of the modelling needed to identify spawning habitats in the English Channel.

**Eastwood, P.D., Meaden, G.J., Carpentier, A. & Rogers, S.I.** 2003. Estimating limits to the spatial extent and suitability of sole (*Solea solea*) nursery grounds in the Dover Strait. *Journal of Sea Research*, 50: 151–165.

**Eastwood, P.D., Meaden, G.J. & Grioche, A.** 2001. Modelling spatial variation in spawning habitat suitability for the sole *Solea solea* using regression quantiles and GIS procedures. *Marine Ecology Progress Series*, 224: 251–266.

The other method of determining nursery grounds relies on simply mapping the locations of where young fish occur:

*Spawning and nursery grounds of selected fish species in UK waters* by J.R. Ellis *et al*. (2012). (http://cefas.defra.gov.uk/publications/techrep/TechRep147.pdf).

**Geographical area:** The favoured area for this project has been described as "the western waters of Qatar". Although this area may seem easy to conceptualize, there are a number of important points to

mention. Thus, would the investigation be limited to Qatar's EEZ? It might be best to carry out this investigation in conjunction with both (or either) Saudi Arabia and Bahrain, whose waters are strongly linked to each other (and to Qatar's). Where would the northern boundary of the project area best be situated? What would be the optimum spatial scale of the study?

**Data required:**

- Digital outlines of the coast – perhaps for parts of three countries.
- Digital data on at least bathymetry, salinity (by season), water temperatures (by season), bottom substrates (including sediment classes and marine habitats).
- Data on prevailing water currents may be required.
- Data on the locations of young fish of selected species in western Qatari waters for all countries partaking in this pilot project.

**Data sources:** The Ministry of Agriculture is responsible for the collection of landing and market data and for the Fisheries Database. As Qatar appears to have a fairly good idea of its data availability, formats, sources, etc., then sources for most data should be easy to locate. However, it is unlikely that sufficient data will be held on the nursery location preferences for the selected species. These will have to be acquired in some way (see below). If this project were carried out in conjunction with one or two neighbouring countries, the data sourcing would be more complex, although it appears that for both Saudi Arabia and for Bahrain the required marine (physical characteristics) data might exist.

**Methods:** The most important part of the methodology concerns the manner in which nursery areas are established. If complex habitat modelling methods were used, it would be essential to have access to long-term marine sample surveys (at least ten years) that had gathered data from many survey points, and that had measured parameters such as depth, temperature, and bottom sediments. Most importantly, quantitative data on the numbers of fish of different species and sizes that were counted/measured at each sample survey point would be needed. Very few countries have this data. So how might Qatar acquire such data? It is suggested that satisfactory data might be obtained from questionnaire/interviews carried out among a representative number of fishers who use the western Qatari waters. Thus, it seems likely that experienced fishers would be able to locate on a map those specific areas where in the past they had encountered large numbers of young (perhaps undersize) fish of various species. It would be important to do this as accurately as possible. There might also be fishery researchers or environmental scientists who could contribute to this information. The information obtained would need to drawn (digitally) on an appropriate scale base map as a series of small circles showing individual nursery areas, i.e. with perhaps one base map per species.

The exercise would gain value if the power of the GIS could be utilized to calculate and model what marine environmental factors the distribution of the nursery areas best matched up to. There are statistical means of doing this that need to be checked. It might then be possible to find all the locations in western Qatari waters where the identified conditions exist, for example, by looking for areas having specific water depths, a specific range of sediments or habitat type, and perhaps certain water temperatures at particular times of the year, etc. Having identified areas that match up to expected nursery grounds, it might be possible to test the results of the model by asking some fishers to visit these areas at the right time and to confirm whether the nursery location estimations were correctly identified.

**Output or outcomes:** A series of maps showing estimated locations of the nursery grounds for specific fish species. These maps could prove extremely important to any work aimed at identifying areas for marine reserves or for conservation purposes. It would be in the fishers' best longer-term interests to avoid fishing in these areas – certainly at particular times of the year.

**Beneficiaries:** The Ministry of the Environment, groups involved in marine spatial planning, or in following ecosystem-based approaches to fisheries management. The long-term beneficiaries would

be the fishers themselves, and the authorities responsible for food security and for maintaining marine environmental sustainability.

**Proposed agency undertaking the project:** Fisheries Department (Ministry of Environment), perhaps in conjunction with a university-based marine/fisheries research group

**Estimated budget:** Project costs are estimated as per the following table. This assumes that all fish-nursery-ground-related data (except the basic coastline data) must be collected via field surveys, and that any additional analyses deployed would use freely obtainable digital data from local sources. There is also an assumption that hardware and software would be purchased specifically for the pilot project and that it could then be used for subsequent GIS work (in Qatar the hard and software might already exist). Some of these costs would have to be adjusted upwards if three countries were participating in this pilot project (although individual country costs might be reduced).

| Budget item | Details | Costs (US$) |
|---|---|---|
| GIS hardware and software | Computer, UPS, printer, scanner, notepad or tablet, GIS software | 6 000 |
| Questionnaire compilation, data entry and analyses | Staff – 1 person part time for one year | 8 000 |
| Data collection staffing | Staff – 1 part time for one year | 6 000 |
| Travel and accommodation expenses | Accommodation, subsistence, travel costs | 4 000 |
| **Total** | | **24 000** |

**Saudi Arabia**

**Project title**: Mapping the fishing effort of shrimp fishery in the Al Qatir area of Saudi Arabia (i.e. it is assumed that this area is actually called Al Qatif – also spelled Al Qateef).

**Background:** With a total coastline measuring 2 400 kilometres the Kingdom of Saudi Arabia has a long history of commercial fishing. A wide variety of finfish species and crustaceans (mainly shrimp) are caught and landed. At almost 600 km, the coastline of the Gulf is much shorter than that of the Red Sea, although total fish catches are similar for both marine areas. Gulf waters are warmer and shallower than those of the Red Sea. Artisanal fishing dominates in Gulf waters, with there being about 2 000 small vessels (dhows and skiffs) and with 98 percent of fish being caught by these vessels. Dhows fish in inshore and offshore waters using shrimp trawls, wired traps for finfishes, gillnets, handlines and longlines for pelagic species. Skiff fishing methods consist of shrimp trawls, wired finfish traps, small and large gillnets, small and large trolling lines and handlines. The main resources exploited are shrimp (trawls), crabs (various gear types, among which wired traps and gillnets), demersal fishes (traps and gillnets), small and large pelagic species (gillnets, trolling lines and handlines).

For several decades, there has also been a major industrial shrimp fishery in the Gulf, with about 30 boats. Although shrimp catches have been relatively stable in the last decade, in terms of effort inputs these catches have shown a long-term decline. However, recent catches have increased from about 5 000 tonnes from Gulf waters in 2000 to more than 9 000 tonnes in 2007, although associated with these shrimp catches there has been a very large bycatch, mainly of unwanted species or of juvenile fish. Production from shrimp-based aquaculture is now considerably higher than the total marine catches of the species. The long-term decline in this fishery means that shrimp fishing in the Gulf is now only permitted from August to January. Despite these seasonal closures, overfishing by artisanal fishers in shallow coastal waters still occurs.

**Justification:** It is estimated that the waters around the subject area of study (the Al Qatif area) have been subjected to extensive over-fishing of shrimp in recent decades. This has probably occurred because this area is immediately adjacent to the main fishery port on the Gulf (Al Dammam) and because this section of the Gulf shoreline is heavily urbanized and, thus, markets are conveniently located. In addition, the coastal waters (and thus the marine ecosystems) have seen extensive disturbance from projects that have involved major land reclamation, e.g. the King Abdulaziz seaport, the Al Shati urban area, the Al Hamra peninsular, plus extensive reclamation to the north of Tarout.

There is no doubt that this work will have had a considerable negative impact on shrimp habitats. If the marine waters in the Al Qatif area are to be retained for shrimping, and if stocks are to be rebuilt, then it is important to both gain some estimation of present fishing effort and to implement better management controls. Although GIS and other spatial technologies have been used extensively for terrestrial purposes in Saudi Arabia, and for seeking aquaculture locations for shrimp production, almost no spatial analyses have been undertaken for marine fishery purposes.

**Objectives:** To produce data on the present fishing effort being deployed. Although these data might allow for longer-term comparisons to be made with any previous data held, they will definitely provide a baseline against which future fishing effort can be compared. Effort should be measured separately for artisanal fishers and for commercial trawling (if this still takes place). It will be important to measure effort in a uniform way, e.g. by boat numbers for a given time, or person hours, or fishing methods, and to measure effort at different times of the year (seasonally). As well as measuring effort directly, it might be useful to match this effort to catches in some way.

**Geographical area:** Data required and methods would need to be adjusted according to the area that is selected:

1. from the Abu Ali peninsular in the north to approximately the territorial waters of Bahrain in the south; or
2. the smaller area extending from Ras Tanura in the north to offshore from Ad Dammam (or possibly to the boundary with the territorial waters of Bahrain); his smaller area might define the “Al Qatif area of Saudi Arabia”; or
3. the very small area immediately offshore from Al Qatif, i.e. from Ras Tanura to the King Abdulaziz Seaport – which seems to be called Tarout Bay.

**Data required:**

- Base map (or maps) of the coastline in the Al Qatif geographical area. The offshore marine area to be covered by this pilot project needs to be divided into cells. The size of the cells will need to relate to the size of the study area. If the study area is geographical area 1 (above) then 10 × 10 km cells would be appropriate; if 2, then cell size might be 5 × 5 km; and if 3 (above) then cell size could be 2 × 2 km.
- Some indication of fishing effort inputs into each cell. This might be by mean boat hours, mean person hours per week, mean kilometres trawled per week, mean number of traps/pots set per week, port/place of origin of fishers, etc.
- As the above data might need to be collected via questionnaire/interviews, it could be worth acquiring data about species caught (quantity and cell location) at the same time.
- If further GIS-based analyses are required, then data on factors such as marine bottom type, bathymetry, and water temperatures might need to be acquired.

**Data sources:** It is difficult to be precise on sources of available data in Saudi Arabia. The 2010 questionnaire carried out prior to the Qatar workshop indicated that data might be available from the Military Survey, Aramco and KACST. It was also mentioned that “an online vessel tracking and monitoring system was indicated as a proposed project during the 2010 RECOFI spatial planning workshop.” If this system is operational for the Gulf region, then this could provide useful data. It is also difficult to be precise on data availability because there is an acknowledged reluctance to share data between different government agencies.

In order to carry out the suggested pilot project, it would be possible to gather data from field surveys at local ports, i.e. those places where fishers in the Al Qatif area would be based. Data should be gained by interviewing fishers and asking them to complete questionnaires that are aimed at seeking answers to where they fish (indicating the areas fished by use of the map showing marine cells), how often they fish (e.g. by person days per month), their type of fishing vessel, their port of origin, fishing gear used and perhaps some details on their catches (by weight and species). Sample data only should be collected for perhaps one month in three. The confidentiality of each fisher's data would need to be ensured. Questionnaire surveys should be carried out for about a year and should cover enough fishers to make the sample truly representative.

**Methods:**

(i) Produce a base map for the area to be covered by the survey showing the coastline, main settlements or features and the location of the marine area cells (i.e. either 2 × 2 km, 5 × 5 km or 10 × 10 km – see "Geographical area" and "Data required" above).
(ii) Check the data sources shown above and their availability. If not appropriate, then move to bullet (iii) below.
(iii) Work out a timetable for fishing site visits that enables fully representative data to be collected, ideally for a whole year.
(iv) Devise a relevant questionnaire and data collecting sheet. Consider the use of a notepad computer with pre-formed data sheets on which the data can be collected. Otherwise, collect data using manual methods (pen and paper).
(v) Collect data at the times/seasons that will give the most accurate and objective results.
(vi) Enter data on database.
(vii) On a base map showing the coastline of the study area and the survey cells, perform GIS functions that satisfactorily map the data collected.
(viii) Carry out any further analyses required, e.g. it might be possible to show relationships such as that between gear type used and depth of water, or typical catches and distance from home ports.

**Output or outcomes:** Maps showing an estimation of the amount of fishing effort per grid cell in Al Qatif marine waters, i.e. by category of vessel, type of gear used, by port of origin of boat, by season of fishing, depth of water, etc. The information from the data could also be produced in tabular form.

**Beneficiaries:** The main immediate beneficiary would be the Marine Fisheries Department within the Ministry of Agriculture, but benefits would soon accrue to local fishery managers, then, as shrimp fishing became adjusted to a sustainable level, local artisanal fishers would reap the rewards. Eventually, given this type of spatial planning exercise, local marine ecosystems could regain better equilibrium. It is also important to mention that this planned pilot project is only for one small area and it only looks at one species (shrimp). If spatial methodologies prove to be successful, then the methods used can be transposed to other sections of the country's long coastline, or for other marine species.

**Proposed agency undertaking the project:** The Information Technology Department in conjunction with the Ministry of Agriculture (Marine Fisheries Department), Riyadh. It would be ideal if this project could be coordinated at Ad Dammam if there are fisheries/GIS personnel at this location.

**Estimated budget:** Project costs are estimated as per the following table. This assumes that all data (excepting the basic coastline data) must be collected via field surveys, and that any additional analyses deployed would use freely obtainable digital data obtained from local sources. There is also an assumption that hardware and software would be purchased specifically for the pilot project and it could then be used for subsequent GIS work.

| Budget item | Details | Costs (US$) |
|---|---|---|
| GIS hardware and software | Computer, UPS, printer, scanner, notepad or tablet, GIS software. | 6 000 |
| Data collection staffing | Staff – 2 part time for one year | 12 000 |
| Questionnaire compilation, data entry and analyses | Staff – 1 person part time for one year | 8 000 |
| Data collection expenses | Travel and subsistence | 6 000 |
| **Total** | | **32 000** |

**United Arab Emirates**

**Project title:** Identification of the spawning habitats of demersal species in the EEZ of the United Arab Emirates.

**Background:** The marine area of the United Arab Emirates can be divided into two contrasting areas: (i) a 100 km east facing coastline on the Gulf of Oman; and (ii) a much longer (about 1 200 km) predominantly north and north-west facing coast line on the Gulf itself. Conditions in the former area are more typically maritime, having relatively temperate aquatic conditions in an oceanic setting where seas are of variable depths. The Gulf waters have much higher temperature and salinity readings in a very shallow sea. Here, summer water temperatures may reach 35 °C.

With the exception of a small purse seine fishery operating out of Sharjar, the fisheries are all artisanal. More than 5 000 small fishing vessels are based around the coast, and fish are delivered to 46 principal landing sites. These landing sites incorporate facilities for landing, storing, auctioning, wholesaling and retailing the catch while some of the larger landing places/markets also have simple processing facilities for wholesale and retail customers. The most productive marine waters are those inshore areas around the Straits of Hormuz. Fishing methods are varied and include fixed and floating gillnets, hand trolling and drop lines, fixed stake nets and gargoor. It is difficult to estimate annual fish catches because the data are very unreliable. The main objective of fisheries policy is that the activities should be sustainable and that most fish requirements can be sourced from local and national supplies. Other objectives include the banning of destructive fishing practices such as trawling, and the enhancement of local fish populations through the construction of artificial reefs. Fishing effort is controlled through vessel licensing, closed areas and seasons, and a limit on the number of traps per vessel. Recent laws requiring that a United Arab Emirates national be physically present on vessels during fishing operations has also reduced the number of active vessels considerably. These varied methods to restrict fishery activities result from the realization that there are few prospects for further development of the industry.

**Justification:** Fisheries operate almost exclusively at an artisanal level. This means that output is relatively low, that supplies are uncertain and that the scope for meeting the needs of a rapidly rising population are far from satisfactory. If national supplies are to be increased, then important changes in fishery objectives must be made and management must be more effective. At present, deficiencies in fish supplies are made up by imports from Oman. The government gives subsidies to the fishing industry and currently there are no output controls – both of these factors could readily encourage too much fishing.

A comprehensive fisheries survey in 2002 found that demersal catches were, in some areas, only 5 percent of those recorded in a similar 1978 survey. As well as overfishing, it is likely that extensive degradation of the coastline has been caused by intensive human development. This has profoundly affected many coastal ecosystems that were formerly advantageous to fish production and survival. Physical conditions for the fishery are relatively harsh, i.e. with high water temperatures and salinity, and with a recent major problem of harmful algal blooms along significant sections of the coastline. Marine protected areas have been established, mainly in the country's western Gulf waters, with the

purpose of protecting fragile ecosystems and mammals such as dugong. However, there is a potential problem with respect to large marine areas having oil concessions. There is a need for better coordination of marine activities, for better standards of coastal constructions and for improved environmental assessment practices. Despite the dominant role played in the United Arab Emirates economy by oil, the fishing industry retains a significant heritage value and is an important part of the social fabric of many coastal villages.

The rest of this pilot project proposal has not been completed because the project is considered unsuitable, i.e. in terms of the country's marine GIS capacity and in terms of data requirements. Thus, for identifying spawning habitats, there must be evidence of where these are, i.e. through species eggs having been collected via a marine fisheries survey, and this evidence is not forthcoming. The United Arab Emirates (Cairo attendees) have been notified that their proposed pilot project is not possible, and they have been given a detailed attachment explaining the problem and giving advice on what they might do. In order to show why their project is inappropriate, they have been supplied with the following selected references (shown in the text box below). Because of these difficulties, it is suggested that the United Arab Emirates choose another marine capture fisheries pilot project, i.e. preferably from those project suggestions detailed in Annex 1 (above).

**Selected references showing how fish spawning habitats may be established**

The first three surveys rely on the use of underwater microphones to record the spawning sounds of male fish:

a) Identifying sciaenid critical spawning habitats by the use of passive acoustics (www.sefsc.noaa.gov/sedar/download/S18-D15%20Sciaenid%20spawning%20habitats,%20passive%20acoustics.pdf?id=DOCUMENT).
b) **Grabowski, T.B., Boswell, K.M., McAdam, B.J., Wells, R.J.D. & Marteinsdóttir, G**. 2012. Characterization of Atlantic cod spawning habitat and behavior in Icelandic coastal waters. PLoS ONE, 7(12): e51321. doi:10.1371/journal.pone.0051321 (www.plosone.org/article/info%3Adoi%2F10.1371%2Fjournal.pone.0051321).
c) Mapping spawning habitat of spotted sea trout in Tampa Bay(myfwc.com/research/saltwater/fish/spotted-seatrout/mapping/).

The next three methods of spawning ground location rely on habitat modelling techniques:

d) Research aims to protect marine ecosystem. This generally describes some of the modelling needed to identify spawning habitats in the English Channel (www.canterbury.ac.uk/News/newsRelease.asp?newspk=754)
e) **Eastwood, P.D., Meaden, G.J., Carpentier, A. & Rogers, S.I.** 2003. Estimating limits to the spatial extent and suitability of sole (*Solea solea*) nursery grounds in the Dover Strait. Journal of Sea Research, 50: 151–165.
f) **Eastwood, P.D., Meaden, G.J. & Grioche, A.** 2001. Modelling spatial variation in spawning habitat suitability for the sole *Solea solea* using regression quantiles and GIS procedures. Marine Ecology Progress Series, 224: 251–266

The final method of determining spawning grounds relies on simply mapping the locations of where fish eggs occur:

g) Spawning and nursery grounds of selected fish species in UK waters by J.R. Ellis *et al.* (2012) (http://cefas.defra.gov.uk/publications/techrep/TechRep147.pdf).

**Estimated budget:** Because of the problems explained above, costs are likely to be in the range of those outlined for the proposed/suggested projects shown in Annex 1 above (i.e. about US$34 000).

## AQUACULTURE PROJECTS

### Introduction

One of the outputs from the Cairo workshop was that each RECOFI member country should produce proposals for a GIS-based pilot project designed to address an aquaculture problem/issue. Initially, individual issues were identified using the EAA process and then the participants from each country[6] prioritized the main issue that needed addressing and developed an outline for the proposed pilot project.

For each project, recommended steps for following the EAA and ensuring a participatory process may include:

(i) scoping and definition of the system boundaries and the identification of stakeholders;
(ii) identification of the main socio-economic, environmental and governance issues and factors, including integration with other sectors when appropriate and external factors such as climate change that will influence the selection of the aquaculture sites;
(iii) prioritization of the criteria through some form of risk assessment;
(iv) elaboration of an implementation plan for aquaculture zoning and/or assignment of sites taking into account the corresponding implementation process, which includes reinforcing, monitoring and evaluation;
(v) performing a long-term review of zoning and spatial arrangements of aquaculture siting for planning. This whole process must be done within the national or local aquaculture policy goals and regulatory frameworks; the latter often need to be reviewed and modified as a result of such a process.

Prior to and during the scoping process defined above, and especially during the process of identifying main issues and criteria for the spatial planning, it is necessary to review whether the existing legal frameworks concerning the use of coastal zones and related activities support the objectives of the planning process and whether modifications to such legal frameworks are required. Water-use rights, unfettered access to the foreshore, port access rights and regulations for maritime transport are often relevant factors for consideration.

As the Gulf is one waterbody divided into a number of national EEZs and territorial waters, in addition to national pilot projects, there is a need for a regional-scale project to identify the scale of aquaculture that could be carried out in the Gulf and to identify the most suitable areas so that aquaculture development can be carried out responsibly and sustainably. This need would have to be discussed and planned on a regional basis by higher-level decision-makers.

### Bahrain

**Project title**: Identification of potential sites for the development of fish aquaculture in the Kingdom of Bahrain

**Background:** Bahrain consists of an archipelago of islands in the shallow waters of the central Gulf. This archipelago comprises 36 islands covering a total area of 706 $km^2$. The largest island is Bahrain, covering an area of 589.83 $km^2$, which contains the capital Manama and is linked by causeways to neighbouring islands such as Muharraq, Sitra, Umm Na'san and Nabih Salih. The main island is also linked by a causeway to Saudi Arabia. The other large islands of the Bahrain archipelago include Hawar, situated at a distance of 25 km to the southeast of the main island and covering an area of about 52 $km^2$. Bahrain has limited marine space (3 800 $km^2$) and a coastline of only 590 km (including islands), so there is strong competition for the use of these resources. The coastal waters are open with

[6] There were no participants from Iran (Islamic Republic of) or Kuwait so no pilot projects were identified for these countries.

no protected bays or sheltered areas and are generally shallow, with only small deep areas in the form of depressions in the sea floor. Salinities are high, tidal currents and wind velocities are medium to high. In 1979, the National Mariculture Centre was started as a pilot project as a result of cooperation with FAO. The centre is located at Ras Hayan on the southeast coast of Bahrain, and it is under the jurisdiction of the Directorate of Marine Resources. It is the government body that conducts applied and scientific research into aquaculture.

**Justification:** Bahrain has no commercial mariculture activities. The main production output from the National Mariculture Centre consists of juvenile marine fish for export and for local stock enhancement programmes. There is potential for shallow net cage farming in selected areas, but measures for the protection of cages against natural elements need to be considered. The identification of potential sites for commercial juvenile fish production, cage farms and onshore recirculation farms will facilitate aquaculture development, thus minimizing conflict with other users of the coastal and marine resources.

**Objective:** To identify potential sites for the location of a marine fish hatchery, recirculation tank farm and fish cages in Bahrain for the culture of groupers and seabreams, and taking into consideration potential conflicts with other stakeholders and users of the coasts and marine space.

**Geographical area**: Bahrain territorial waters and EEZ.

**Data required**:

- base map with coastline, topography and bathymetry;
- mean annual water temperature (seawater and marine groundwater);
- mean annual water salinity (seawater and marine groundwater);
- mean annual algal concentrations;
- mean annual tidal fluctuations;
- meteorological data (wind direction, frequency and strength);
- industrial discharge points;
- marine navigational channels;
- harbours;
- coastal building developments;
- land-use map;
- electricity transmission and distribution network;
- water transmission and distribution network;
- marine habitat mapping (coral reefs, seagrass, mangroves, etc.);
- marine protected areas;
- other marine and coastal areas having special designations.

**Data sources:** Directorate of Fisheries and Marine Resources; Environmental Assessment and Planning Directorate; Public Commission for Protection of Marine Resources; Environment and Wildlife; General Directorate of Planning. Survey and Land Registration Directorate; GEOMATEC (a subsidiary of the Bahrain Centre for Studies and Research [BCSR]); the MARGIS database; satellite image analyses, field data collection, etc.

**Methods**:

1. Identify site selection criteria.
2. Identify data sources, collect data from data sources, input data into GIS.
3. Identify gaps in data, collect field data.
4. Purchase satellite images, analyse satellite images for potential coastal sites.
5. Undertake satellite image analysis of coastal areas away from sensitive habitats, industrial/domestic development, wadis, etc.
6. Collect other data from data sources or the field.

7. Develop:
    a. land site-selection criteria;
    b. sea site-selection criteria.
8. Using GIS, prepare layered maps of the data:
    a. identify exclusion zones;
    b. identify sensitive and conflict zones with buffers;
    c. identify potential zones with weightings;
    d. prioritise the aquaculture zones.
9. Map of other coastal and marine users, identify potential areas with low conflict.
10. Prepare an aquaculture atlas of potential sites.
11. Undertake carrying capacity modelling on the selected zones.

**Outputs or outcomes**:

- The addition of potential aquaculture sites to the marine atlas for Bahrain with initial estimates of the scale of potential production.
- Identified sites for potential investors.

**Expected benefits:**

- Identified suitable aquaculture sites for potential investors.
- Estimated location and scope of potential aquaculture for the Directorate of Fisheries and Marine Resources.
- Aquaculture potential for MSP maps for the MarGIS database and marine atlas.

**Proposed agency undertaking the project**: The National Mariculture Centre, Directorate of Fisheries and Marine Resources.

**Estimated budget**

| Budget item | Details | Costs (US$) |
|---|---|---|
| Staff | 2 staff part time | 20 000 |
| Data purchases | Satellite images, ministry data, meteorological data | 5 000 |
| Data collection | Field data collection | 5 000 |
| Analysis | 1 person part time | 10 000 |
| Expenses | Software and models. Field data expenses | 10 000 |
| Other | Atlas preparation and printing | 10 000 |
| **Total** | | **60 000** |

**Time frame for implementation**: Less than two years.

**Proposed funding source**: Directorate of Fisheries and Marine Resources.

**Iraq**

**Project title**: Identification of potential sites on the Iraqi coast for a marine fish hatchery to produce fry for the restocking of Iraqi waters and, in the future, a marine recirculation farm to on-grow fish to market size for human consumption.

**Background:** Iraq has diverse water resources that are thought suitable for enhancing its fishery resources, especially in inland waterbodies. These latter cover 600 000–700 000 ha and comprise natural lakes (39 percent), dams and reservoirs (13.3 percent), rivers and their branches (3.7 percent), and marshes (44 percent). The Tigris and Euphrates Rivers, including also the country's tributaries, marshes, dams and reservoirs, comprise Iraq's main water source. Iraq has a limited coastline of about

59 km bordering the Gulf, with a marine water surface area of about 700 $km^2$, which represents its EEZ.

**Justification:** Marine aquaculture has not been developed at all due to a lack of extensive suitable sites in marine waters. However, the aquaculture subsector could be important as an alternative source of fish food, particularly as fish from traditional capture fisheries (i.e. fishing activities that are carried out in the Gulf – Shatt-Al-Arab by the private sector) is not able to cope with the fish demand. Despite the fact that the prevailing arid climate is a major hurdle, with high evaporation rates (especially in the summer months) and extreme temperature fluctuations, brackish-water and marine fish culture could be undertaken in intensive recirculated aquaculture systems (RAS). The main species of interest are grouper, seabream and silver pomfret.

**Objective**: To identify potential suitable areas for the location of a marine fish hatchery, and a recirculation tank farm along the coast of Iraq, to produce fry for restocking of Iraqi waters and for on-growing to market size for human consumption.

**Geographical area**: Iraq territorial waters (EEZ).

**Data required**:

- base map with topography, coastline and bathymetry;
- mean annual water temperatures (seawater and marine groundwater);
- mean annual water salinity (seawater and marine groundwater);
- mean annual tidal fluctuations;
- meteorological data (wind direction frequency and strength);
- industrial discharge points;
- coastal building developments;
- land-use map
- other users of the coastline.

**Data sources:** The General Board for Fish Resource Development and the Marine Science Centre, Basrah. Other data may be available from:

- Biology Department, College of Education, Ibn-Al-Haytham;
- Fisheries Department, Ministry of Science and Technology;
- Biology Department, College of Sciences, Basrah University/;

**Methods**:

(i) Identify site selection criteria.
(ii) Identify data sources, collect data from data sources, input data into GIS.
(iii) Identify gaps in data, collect field data.
(iv) Purchase satellite images, analyse satellite images for potential coastal sites.
(v) Undertake satellite image analysis of coastal areas away from sensitive habitats, industrial/domestic development, wadis, etc.
(vi) Using GIS, prepare layered maps of the data:
    a. identify exclusion zones;
    b. identify sensitive and conflict zones with buffers;
    c. identify potential zones with weightings;
    d. prioritize the aquaculture zones.
(vii) Map of other coastal and marine users, identify potential areas with low conflict.
(viii) Prepare an aquaculture atlas of potential sites.

**Outputs or outcomes**:

- Aquaculture atlas for Iraq with initial estimate of potential production scale.
- Identified sites for potential investors.

**Proposed agency undertaking the project:** The General Board for Fish Resource Development.

**Estimated budget:**

| Budget item | Details | Costs (US$) |
|---|---|---|
| Staff | 2 staff part time | 15 000 |
| Data purchase | Satellite images, Ministry data, meteorological data | 2 500 |
| Data collection | Field data collection | 2 500 |
| Analysis | 1 person part time | 5 000 |
| Expenses | Software and models. Field data expenses | 7 500 |
| Other | Atlas preparation and printing | 5 000 |
| **Total** | | **37 500** |

**Time frame for implementation:** One year.

**Proposed funding source:** The General Board for Fish Resource Development.

**Oman**

**Project title**: Integrated coastal planning and management of mariculture development in the Sultanate of Oman

**Background:** Oman has coasts that border both the Arabian Sea and also a smaller coastline that borders the more sheltered Gulf of Oman. A very small area in the north of Oman has coastal waters on the Gulf that are characterized by extreme meteorological and hydrological conditions. By contrast, the waters of the Gulf of Oman and the Arabian Sea are more oceanic in nature with hydrological parameters exhibiting much smaller seasonal variation. Aquaculture in Oman is currently at an early stage of development, both in terms of basic or applied research and in private sector growth. The Government, in collaboration with FAO, developed a national strategy for aquaculture development in 2007. Since 1997, the Ministry of Fisheries Wealth has engaged in seven major research projects on fish and shellfish culture. Experience gained from ministry-funded projects and subsequent technology transfer has stimulated entrepreneurial interest in commercial aquaculture ventures.

**Justification:** Oman has identified aquaculture as being a key pillar to diversify its national economy beyond the hydrocarbon sector. In addition to the controls placed on certain parts of Oman's artisanal fishery, it is recognized that development of a lively aquaculture industry will not only increase seafood production but perhaps also decrease fishing pressure on high-value commercial species.

The Ministry of Fisheries Wealth has developed an aquaculture atlas that includes the entire coastline and is illustrated with satellite imagery information relevant for site suitability for aquaculture operations and infrastructure needs for commercial aquaculture. The atlas is available on the RAIS website and the Ministry of Fisheries website of Oman. (www.mofw.gov.om/AquaOman/public/images/ATLAS%20final%206%20August%202010.pdf).
Although the atlas identifies potentially suitable sites for aquaculture development, it does not fully take into consideration potential conflicts from other users of the coastline. Therefore, there need to be further studies to ensure that the selected sites do not cause major conflicts.

**Objective**: To identify potentially suitable areas for the location of recirculation tank farms and fish cages in Oman waters, taking into consideration potential conflicts with other stakeholders and users of the coasts and marine space.

**Geographical area**: Oman territorial waters and EEZ.

**Data required**:

- base map with topography, coastline and bathymetry;
- industrial discharge points;
- marine navigation channels;
- harbours;
- coastal building developments;
- land-use map;
- roads;
- population density and distribution;
- dredging areas;
- marine habitat mapping (coral reefs, seagrass, mangroves, etc.);
- marine protected areas and other restriction zones.

**Data sources:** The Ministry of Fisheries Wealth; Ministry of Housing; Ministry of Tourism; Ministry of Environment; Ministry of Gas; satellite image analyses, field data collection, etc.

**Method**s:

(i) Identify site selection criteria, identify data sources, collect data from data sources, input data into GIS.
(ii) Identify gaps in data, collect field data.
(iii) Purchase satellite images, analyse satellite images for potential coastal sites.
(iv) Undertake consultation with other stakeholders.
(v) Satellite image analysis of coastal areas away from sensitive habitats, industrial/domestic development, land use, etc.
(vi) Using GIS:
    a. prepare layered maps of the data;
    b. identify exclusion zones
    c. identify sensitive and conflict zones with buffers
    d. identify potential zones with weightings.
(vii) Map of other coastal and marine users, identify potential areas with low conflict.

**Outputs or outcomes**:

- Updated aquaculture atlas for Oman with initial estimate of potential production scale.
- Identified sites for potential investors.

**Expected benefits:**

- Identified suitable aquaculture sites for potential investors with the consideration of other users of the coastline.

**Proposed agency undertaking the project**: The Aquaculture Center together with the Aquaculture Development Department of the General Directorate of Fisheries Research under the directives of the Ministry of Fisheries Wealth.

**Estimated budget:**

| Budget item | Details | Costs (US$) |
|---|---|---|
| Staff | 2 staff part time | 20 000 |
| Data purchase | Satellite images, Ministry data, land-use data | 5 000 |
| Data collection | Field data collection | 5 000 |
| Analysis | 1 person part time | 10 000 |
| Expenses | Software and models. Field data expenses | 10 000 |
| Other | Atlas preparation and printing | 10 000 |
| **Total** | | **60 000** |

**Time frame for implementation**: Less than two years.

**Proposed funding source**: Ministry of Fisheries Wealth.

**Qatar**

**Project title**: Identification of suitable sites for mariculture in Qatar territorial waters

**Background:** Qatar is situated on a peninsula on the western side of the Gulf and it has a coastline of 463 km. The country shares resources with its close neighbours of Saudi Arabia, Bahrain and the United Arab Emirates. Similar to those of other countries in the region, the sea area and coastline of Qatar are characterized by extreme meteorological and hydrological conditions with water temperatures exceeding 33 °C in summer, plus very high evaporation rates and high salinities. Seasonal variation in hydrological parameters is also high with water temperatures varying from about 19 °C in winter to 32 °C in summer. Aquaculture activity in Qatar started in 1988 with the construction of a small, governmental experimental aquaculture research facility in cooperation with experts from the Japanese International Cooperation Agency (JICA), called the Doha Aquaculture Centre. The centre carries out research on selected species suitable for fish culture according to their price and demand on the local market. Currently, the private sector focuses on Nile tilapia (*Oreochromis niloticus*) aquaculture. Most of the private farms are located in the southwest of the country. The Fisheries Department has recently constructed a marine resources research centre at Rasmutback, north of Al Khor. Research and training, which are the responsibility of the Department of Fisheries, concentrate mainly on site selection, identifying suitable culture species, growth studies, controlled larval rearing, disease control and management. Qatar University offers a graduate-level course in marine science to train graduates in fisheries and aquaculture.

**Justification:** The continuous increase in fish consumption and the demand for fish in Qatar needs to be addressed through aquaculture production. The Department of Fisheries is planning new experimental projects for the growth of aquaculture industries as profitable ventures. The natural resources for aquaculture are yet to be exploited and they require pioneering efforts both from the government and the private sector.

At present, Qatar has no commercial aquaculture activities and there are no large-scale commercial mariculture facilities. The main aquaculture production output consists of small-scale production of freshwater fish. The coastal waters are open with no protected bays or sheltered areas and are generally shallow. Salinities are high, tidal currents and wind velocities are medium to high.

There are potential sheltered areas for net cage farming in the west (near the border with Saudi Arabia), and some more exposed areas in the northwest, but measures for protection of cages against natural elements need to be considered. The identification of potential sites for commercial juvenile fish production, cage farm and onshore recirculation farms will facilitate aquaculture development allowing for diversification and food security.

**Objective**: To identify potentially suitable areas for the location of a marine fish hatchery, recirculation tank farms and fish cages in Qatar, i.e. for the culture of groupers and seabreams, and taking into consideration potential conflicts with other stakeholders and users of the coast and marine space.

**Geographical area**: Qatar territorial waters and EEZ.

**Data required**:

- base map with topography, coastline and bathymetry;
- mean annual water temperatures (seawater and marine groundwater);

- mean annual water salinity (seawater and marine groundwater);
- mean annual algal concentrations;
- mean annual tidal fluctuations;
- meteorological data (wind direction frequency and strength);
- industrial discharge points;
- marine navigation channels;
- harbours;
- coastal building developments;
- land-use map;
- marine habitat mapping (coral reefs, seagrass, mangroves, etc.);
- marine protected areas and other restricted zones.

**Data sources:** Fisheries Department; Ministry of Municipal Affairs and Agriculture; GIS Center of the Ministry of Municipal and Urban Planning. Environmental, physical or statistical (socio-economic) data are collected by respective agencies in Qatar. Most of the data are in GIS format and can be shared by all governmental agencies connected to GIS-Net via high-speed fibre. Satellite image analyses, field data collection, etc.

**Methods:**

(i) Identify site selection criteria.
(ii) Identify data sources, collect data from data sources, input data into GIS.
(iii) Identify gaps in data, collect field data.
(iv) Purchase satellite images, analyse satellite images for potential coastal sites.
(v) Undertake satellite image analysis of coastal areas away from sensitive habitats, industrial/domestic development, wadis, etc.
(vi) Using GIS:
  a. develop layered maps of the data;
  b. identify exclusion zones;
  c. identify sensitive and conflict zones with buffers;
  d. identify potential zones with weightings.
(vii) Map of other coastal and marine users, identify potential areas with low conflict.
(vii) Prepare an aquaculture atlas of potential sites.

**Outputs or outcomes:** Aquaculture atlas for Qatar with an initial estimate of the potential production scale and type of culture system.

**Expected benefits:**

- Identified suitable aquaculture sites for potential investors.
- Estimate of the location and scope of potential aquaculture for the Fisheries Department, Ministry of Municipal Affairs and Agriculture.
- Addition of aquaculture potential to MSP maps for the GIS Center of the Ministry of Municipal and Urban Planning.

**Proposed agency undertaking the project:** Fisheries Department, Ministry of Municipal Affairs and Agriculture.

**Estimated budget:**

| Budget | Details | Costs (US$) |
|---|---|---|
| Staff | 2 staff part time | 25 000 |
| Data purchase | Satellite images, Ministry data, meteorological data | 7 500 |
| Data collection | Field data collection | 7 500 |
| Analysis | 1 person part time | 15 000 |
| Expenses | Software and models. Field data expenses | 15 000 |
| Other | Atlas preparation and printing | 15 000 |
| **Total** | | **85 000** |

**Time frame for implementation:** Less than two years.

**Proposed funding source**: Fisheries Department, Ministry of Municipal Affairs and Agriculture.

**Saudi Arabia**

**Project title:** Identification of sites for mariculture in the Gulf area of the Kingdom of Saudi Arabia, i.e. near Ras Abo.

**Background:** Saudi Arabia has a coastline of 800 km in the Gulf (with an additional 1 840 km on the Red Sea). This provides opportunities for both capture fisheries as well as offshore and land-based aquaculture development. Because of the potentially favourable environment for fish farming, the Ministry of Agriculture has identified aquaculture as a priority economic sector. Aquaculture in Saudi Arabia is a relatively new activity. The Indian white prawn is by far the most important mariculture species in the region and is cultured only in Saudi Arabia, where the world's largest prawn farm exists (on the Red Sea). However, aquaculture is far less developed on the Gulf coast. Aramco is constructing a marine fish and shrimp hatchery on the Gulf that will be able to provide seed for new aquaculture developments and for restocking in Saudi territorial waters.

**Justification:** Saudi Arabia has considerable potential for expanding coastal aquaculture – it has long coastlines with relatively few alternative economic uses, a range of water temperature regimes for culturing a mixture of fish and shrimp species, cheap energy and (albeit rising) labour costs and access to strong national, regional and international markets. Led by a number of pioneering Saudi companies, this potential is beginning to be realized. Aquaculture development is focused on the Red Sea coast but there are also opportunities on the Gulf coast, and this would allow diversification away from oil, assist with food security and provide employment for fishers during the closed season. Development of aquaculture on the Gulf coast would allow the culture of Gulf fish species. Development could be onshore, semi-intensively in ponds or intensively in recirculation tanks, or off the coast and offshore in cages but away from oil drilling facilities.

**Objective**: To identify potentially suitable areas for the location of semi-intensive pond farms, recirculation tank farms and offshore fish cages in Gulf waters, i.e. for the culture of groupers and local seabreams, and taking into consideration potential conflicts with other stakeholders and users of the coast and marine space.

**Geographical area**: Territorial waters and EEZ of Saudi Arabia.

**Data required**:

- base map with topography, coastline and bathymetry;
- mean annual water temperatures (seawater and marine groundwater);
- mean annual water salinity (seawater and marine groundwater);
- mean annual algal concentrations;
- mean annual tidal fluctuations;
- meteorological data (wind direction frequency and strength);
- industrial discharge points;
- marine navigation channels;
- harbours;
- coastal building developments;
- land-use map;
- oil drilling facilities;
- marine habitat mapping (coral reefs, seagrass, mangroves, etc.);
- marine protected areas and other restriction zones.

**Data sources:** Department of Aquaculture (DA) (an agency under the Office of the Deputy Ministry of Fisheries Affairs); Ministry of Municipalities and Rural Affairs; Coast Guard; satellite image analyses, field data collection, etc.

**Method**s:

(i) Identify site selection criteria.
(ii) Identify data sources, collect data from data sources, input data into GIS.
(iii) Identify gaps in data, collect field data.
(iv) Purchase satellite images, analyse satellite images for potential coastal sites.
(v) Undertake satellite image analysis of coastal areas away from sensitive habitats, industrial/domestic development, wadis, etc.
(vi) Using GIS:
    a. develop layered maps of the data;
    b. identify exclusion zones;
    c. identify sensitive and conflict zones with buffers;
    d. identify potential zones with weightings.
(vii) Map of other coastal and marine users, identify potential areas with low conflict.
(viii) Prepare an aquaculture atlas of potential sites.

**Outputs or outcomes**:

- Aquaculture atlas for Saudi Arabian coastal waters with initial estimate of potential production scale.
- Identified sites for potential investors.

**Expected benefits:**

- Investors and developers for the identification of potential areas, potential type of aquaculture facilities and scale of production.
- Department of Aquaculture for planning and licensing purposes.

**Proposed agency undertaking the project**: GIS and Remote Sensing Department of the Ministry of Agriculture together with the Department of Aquaculture, an agency under the Office of the Deputy Ministry of Fisheries Affairs within the Ministry of Agriculture.

**Estimated budget:**

| Budget item | Details | Costs (US$) |
|---|---|---|
| Staff | 2 staff part time for 4 months | 20 000 |
| Data purchase | Satellite images, ministry data, meteorological data | 5 000 |
| Data collection | Field data collection | 5 000 |
| Analysis | 1 person part time | 10 000 |
| Expenses | Software and models. Field data expenses | 10 000 |
| Other | Atlas preparation and printing | 10 000 |
| **Total** | | **60 000** |

**Time frame for implementation**: Less than two years.

**Proposed funding source**: Agricultural Development Fund of Saudi Arabia and the Department of Aquaculture or Agricultural Development Fund.

**United Arab Emirates**

**Project title:** Identification of potential aquaculture sites to avoid/minimize effects of red tides

**Background:** The United Arab Emirates has a long, sheltered coastline that borders the Gulf, and also a smaller coastline that borders the more oceanic Gulf of Oman. The sea area and coastline bordering the Gulf is characterized by extreme meteorological and hydrological conditions, with water temperatures exceeding 35 °C in summer (but dropping to 18 °C in winter), very high evaporation rates and high salinities. By contrast, the east coast of the United Arab Emirates, bordering the Gulf of Oman, is much more oceanic in nature with hydrological parameters exhibiting much smaller seasonal variation. However, this east coastal and sea area is small in comparison with the Gulf coast.

Aquaculture activities in the United Arab Emirates started with the establishment of the Marine Environment Research Centre (MERC) in 1984. The MERC was initially supported with technical cooperation from the Japan International Cooperation Agency (JICA). The role of the MERC includes conservation, replenishment and development of marine resources in the territorial waters of the country. Recently, a large recirculation sturgeon farm has been constructed in Abu Dhabi designed for a capacity of 32 tonnes of caviar per year and an annual production of 490 tonnes of sturgeon. The farm has been designed and is operated by United Food Technologies AG, as part of United Food Technologies International, a German-Arabic joint venture located in Beirut, Lebanon. The Khalifa Bin Zayed Centre for Marine Research in Umm Al Quwain is being developed and will be affiliated to the Ministry of Environment and Water. This centre will work on research and studies to produce fish fry for release as fish fingerlings in order to increase fish production, and it will study marine environment pollutants.

**Justification:** The United Arab Emirates has developed commercial mariculture activities producing Mediterranean seabass and bream and local breams; however, production is low compared to the potential. Coastal Gulf waters are open, having few protected bays or sheltered areas, and are generally shallow, with deep areas located far from shore. Salinities are high, and tidal currents and wind velocities are medium to high. There is a potential for net cage farming in selected areas, but measures to avoid high-risk areas having algal blooms must be taken, or consideration must be given to the use of submersible cages. The identification of potential sites for commercial juvenile fish production, cage farms and onshore recirculation farms will facilitate aquaculture development, as well as helping to minimize conflict with other users of the coastal and marine resource. The development of aquaculture, especially mollusc production (oysters, mussels, pearl oysters, etc.), will utilize the high algal concentrations and be a measure to mitigate algal blooms.

**Objective**: To identify potentially suitable areas for the location of recirculation tank farms and fish cages in the waters of the United Arab Emirates, i.e. for the culture of groupers and seabreams, and taking into consideration the risk of algal blooms, potential conflicts with other stakeholders and users of the coasts and marine space.

**Geographical area**: Territorial waters and EEZ of the United Arab Emirates.

**Data requirements**:

- base map with topography, coastline and bathymetry;
- mean annual water temperatures (seawater and marine groundwater);
- mean annual water salinity (seawater and marine groundwater);
- mean annual algal concentrations and high risk algal bloom areas;
- mean annual tidal fluctuations;
- meteorological data (wind direction frequency and strength);
- industrial discharge points;
- marine navigation channels;
- harbours;

- coastal building developments;
- land-use map
- marine habitat mapping (coral reefs, seagrass, mangroves, etc.);
- marine protected areas.

**Data source:** Marine Resources Research Centre (MRRC); Ministry of Environment and Water; Institution of Research and Strategic Planning, The Ministry of Higher Education and Scientific Research. There is sea surface temperature (SST) and Chlorophyll-a satellite imagery available for the country (at: www.moew.gov.ae). Satellite image analyses, field data collection, etc.

**Methods**:

(i) Identify site selection criteria.
(ii) Identify data sources, collect data from data sources.
(iii) Input data into GIS.
(iv) Identify gaps in data, collect field data.
(v) Purchase satellite images, analyse satellite images for potential coastal sites.
(vi) Satellite image analysis of coastal areas away from sensitive habitats, industrial/domestic development, wadis, etc.
(vii) Using GIS:
    a. prepare layered maps of the data;
    b. identify exclusion zones;
    c. identify sensitive and conflict zones with buffers;
    d. identify potential zones with weightings.
(viii) Map of other coastal and marine users, identify potential areas with low conflict.
(ix) Prepare an aquaculture atlas of potential sites.

**Outputs or outcomes**:

- Aquaculture atlas for the United Arab Emirates with initial estimate of potential production scale.
- Identified sites for potential investors.

**Expected benefits:**

- Identified suitable aquaculture sites for potential investors, taking into consideration the risk of algal blooms.
- Estimate of the location and scope for potential aquaculture for the Fisheries Department, Ministry of Environment and Water.
- Aquaculture atlas available for the Government for planning purposes and available for investors to select potential sites.

**Proposed agency undertaking the project:** Khalifa Bin Zayed Centre for Marine Research in Umm Al Quwain.

**Estimated budget:**

| Budget item | Details | Costs (US$) |
|---|---|---|
| Staff | 2 staff part time | 30 000 |
| Data purchase | Satellite images, Ministry data, meteorological data | 7 500 |
| Data collection | Field data collection | 7 500 |
| Analysis | 1 person part time | 15 000 |
| Expenses | Software and models. Field data expenses | 15 000 |
| Other | Atlas preparation and printing | 15 000 |
| **Total** | | **90 000** |

**Time frame for implementation:** Less than two years.

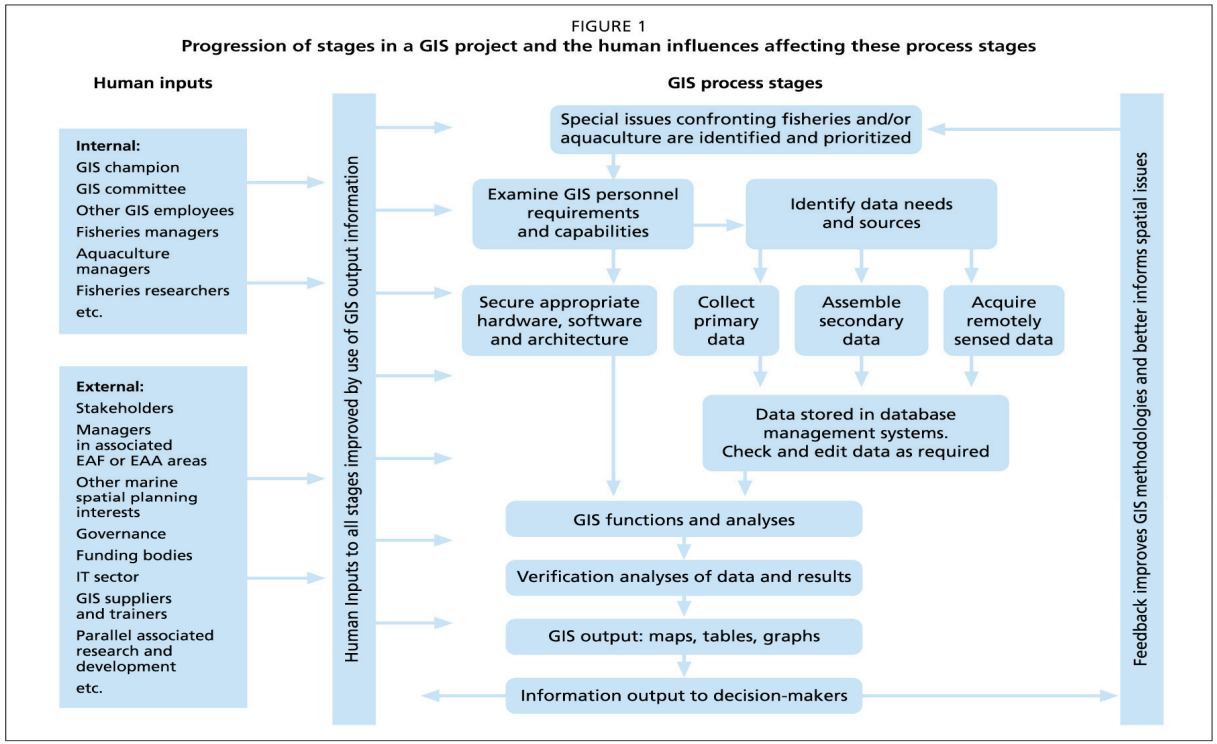
**Proposed funding source:** Fisheries Department, Ministry of Environment and Water.

**Annex 2**

## MAIN CONSIDERATIONS IN DESIGNING A SUITABLE GIS ARCHITECTURE

Figure 1 shows the progression of stages through a GIS project and the human influences affecting these process stages. The left-hand column divides all the human inputs into internal (from within the group or organization) and external inputs (outside sources that may influence the GIS process stages). The main body of the right-hand flow diagram shows the linkages among successive stages that will typically be performed during the completion of any individual GIS-based project. It is important to note the feedback loop, which essentially means that the final information output from the GIS can either: (i) be directed towards any of the human inputs so that they are better informed on spatial-based matters relating to fisheries or aquaculture; or (ii) inform any further GIS work, e.g. perhaps as a result of models developed or any methods used.

FIGURE 1
**Progression of stages in a GIS project and the human influences affecting these process stages**




*Source:* Meaden, G.J. & Aguilar-Manjarrez, J., eds. 2013. *Advances in geographic information systems and remote sensing for fisheries and aquaculture.* Summary version. FAO Fisheries and Aquaculture Technical Paper No. 552. Rome, FAO. 98 pp. Includes a CD–ROM containing the full document (425 pp.). (also available at www.fao.org/docrep/017/i3102e/i3102e00.htm).

**Annex 3**
Exclusive economic zones of RECOFI member countries


*Sources:*

**British Oceanographic Data Centre.** 2008. General Bathymetric Chart of the Oceans. In: *BODC* [online]. UK. [Cited 30 June 2013]. www.bodc.ac.uk/data/online_delivery/gebco

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**Group photograph of workshop participants**

**Members of RECOFI**: Bahrain (Abdulkarim Al-Radhi, Ahmed Abdulwahab Al-Radhi); Iraq (Tareq Hasan Al-Rubaye, Arwa Ali Majeed); Oman (Yahya Saif Hamdan Al-Wahaibi); Qatar (Shekha Darwish Saeed, Abdul Rahman Siddiq Al Bin Ali); Saudi Arabia (Mahmood Abdulaziz Alnoori, Khalid Saleh Alshaye, Mohamed Ibrahim Othaibi); the United Arab Emirates (Ebrahim Abdulla Aljamali, Mohamed Abdelrahim AL Zarouni). **FAO: staff** (José Aguilar-Manjarrez, Fabio Carocci, Hebatallah Fahmy, Piero Mannini, Cherif Toueilib). **International consultants** (Geoffery J. Meaden, Patrick White). **National consultant on GIS** from Qatar (Peter Longdill). **Observer/resource person** from the United Kingdom of Great Britain and Northern Ireland (Justin Saunders).

**The Regional Technical Workshop on a Spatial Planning Development Programme for Marine Capture Fisheries and Aquaculture, held in Cairo, the Arab Republic of Egypt, from 25 to 27 November 2012, was attended by 12 delegates from 6 member countries of the Regional Commission for Fisheries (RECOFI) and FAO. The workshop achieved four objectives: (i) it created awareness and initiated capacity building through a technical seminar on spatial planning for marine capture fisheries and aquaculture – it received feedback from each RECOFI country presentation on recent and relevant spatial planning projects; (ii) it presented the results and analysis of the "RECOFI Spatial Planning Development Programme for Marine Capture Fisheries and Aquaculture Questionnaire Survey"; (iii) it prepared and finalized a "Proposal for a Spatial Planning Development Programme for Marine Capture Fisheries and Aquaculture" in RECOFI member countries based on the survey outcomes, workshop deliberations and brainstorming; and (iv) it identified potential pilot projects on marine capture fisheries and aquaculture, which were later elaborated in detail by international consultants after the workshop and in consultation with workshop participants.**