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Marine pollution and water quality monitoring in Myanmar – assessment and bridging of capacity needs

Norwegian Institute for Water Research
– an institute in the Environmental Research Alliance of Norway

REPORT

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Abstract
The Bay of Bengal Large Marine Ecosystem (BOBLME) project of the Food and Agricultural Organization of the United Nations (FAO) and the Norwegian Institute for Water Research (NIVA) agreed on a project for improving knowledge base and enhancing capacity to address marine pollution and water quality monitoring issues in Myanmar. More specifically, NIVA experts visited Myanmar and worked together with experts from University of Yangon, Department of Chemistry, to describe the most important needs for capacity building. Significant capacity needs were identified and a plan for following up this is presented.

4 keywords, Norwegian	4 keywords, English
1. Myanmar	1. Myanmar
2. BOBLME	2. BOBLME
3. Marin overvåking	3. Marine monitoring
4. Kystsoneplanlegging	4. Integrated coastal zone management

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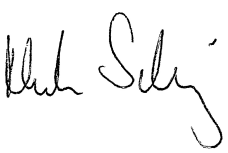

Research Manager
Mr. Morten Schaanning

Marine pollution and water quality monitoring in Myanmar – assessment and bridging of capacity needs

Preface

This project is funded by the Bay of Bengal Large Marine Ecosystem (BOBLME) project of the Food and Agricultural Organization of the United Nations (FAO) for the purpose of enhancing the capacity on monitoring marine pollution and water quality in Myanmar.

Responsible officer at FAO has been regional coordinator of the BOBLME Project Dr. Chris O'Brien. Main contact at the University of Yangon has been Pro-Rector Dr. Kyaw Naing. NIVA's main contact person has been Research Director Dr. Kristoffer Næs

Oslo, 18-02-2015

Kristoffer Næs

Contents

Abbrevations

BOBLME	Bay of Bengal Large Marine Ecosystem
EHS	Environment, Health and Safety
EU WFD	European Union Water Framework Directive
FAO	Food and Agricultural Organization of the United Nations
GIS	Geographic information system
ICP-MS	Inductively Coupled Plasma-Mass Spectroscopy
ICZM	Integrated Coastal Zone Management
IMR	Institute for Marine Research, Bergen, Norway
IWRM	Integrated Water Resources management
MoCE	Norwegian Ministry of Climate and Environment
MOECAF	Myanmar Ministry of Environmental conservation and Forestry
MPA	Marine protected area
NIVA	Norwegian Institute for Water Research, Oslo, Norway
NORAD	Norwegian Agency for Development Cooperation
NWFD	National Water Framework Directive
PMG	Programme management Group
POPs	Persistent Organic Pollutants
SOOP	Ships of opportunity

Summary

Myanmar, Bangladesh, India, Indonesia, Malaysia, Maldives, Sri Lanka and Thailand are working together through the Bay of Bengal Large Marine Ecosystem (BOBLME) project to better the lives of the coastal populations through improved regional management of the Bay of Bengal environment and fisheries. In the coastal regions of Myanmar, sewage, excess nutrients from agriculture and aquaculture, chemical fertilizer residue, POPs, plastics, medical wastes, etc. are considered as main components of land-based source for coastal pollution. The work plan of the BOBLME project envisages capacity development in water quality monitoring to be undertaken in Myanmar. As part of this the Food and Agricultural Organization of the United Nations (FAO) and the Norwegian Institute for Water Research (NIVA) agreed on a project for improving the knowledge base and enhancing capacity to address marine pollution and water quality monitoring issues in Myanmar. More specifically, NIVA experts visited Myanmar and worked together with experts from University of Yangon, Department of Chemistry, to describe the most important needs for capacity building.

The following overall conclusions can be drawn from the discussions regarding needs for performing marine water quality monitoring in Myanmar:

- Significant capacity needs exist on many levels in order to perform coastal zone management activities in compliance with international standards
- The needs include development of a framework for integrated coastal zone management, training and mentoring, laboratory upgrading, including instrumentations and infrastructure/equipment for field work
- Capacity development must include and coordinate with BOBLME objectives
- Bridging the capacity needs can benefit substantial with coordination f. ex. with the just started "Integrated Water Resources Management – Institutional Building and Training" under the Norwegian – Myanmar cooperation
- Bridging capacity need is dependent on financial support. This has to be worked on under the Norwegian – Myanmar environmental cooperation.
- Contact with Norwegian officials will be continued in order to establish cooperative programs within marine water quality monitoring in Myanmar

1. Introduction

1.1 Background

Myanmar, Bangladesh, India, Indonesia, Malaysia, Maldives, Sri Lanka and Thailand are working together through the Bay of Bengal Large Marine Ecosystem (BOBLME) project to better the lives of the coastal populations through improved regional management of the Bay of Bengal environment and fisheries. In 2010 a working group was formed to identify needs and capacity building priorities in order to develop common understanding of the state of the Bay of Bengal's coastal water quality and the main sources of pollution impacting on it. To that end, a study on the status of marine and coastal pollution in Myanmar was completed in 2011. In the coastal regions of Myanmar, sewage, excess nutrients from agriculture and aquaculture, chemical fertilizer residue, POPs, plastics, medical wastes, etc. were considered as main components of land-based source for coastal pollution. This was further elaborated in a research paper by Myanmar scientists led by Dr. Kyaw Naing of the Department of Chemistry at Yangon University (BOBLME 2011).

1.2 Objectives

The work plan of the BOBLME project envisages capacity development in water quality monitoring to be undertaken in Myanmar. As part of this the Food and Agricultural Organization of the United Nations (FAO) and the Norwegian Institute for Water Research (NIVA) agreed on a project for improving knowledge base and enhancing capacity to address marine pollution and water quality monitoring issues in Myanmar. More specifically, NIVA experts visited Myanmar and worked together with experts from Myanmar to describe the most important needs for capacity building. This was conducted through capacity need assessment, a seminar and a plan for capacity development.

1.3 Project organizing

The project was organized as a 4 day visit to Myanmar, June 10 to June 13 2014, with an up-front preparatory phase and a post-visiting phase for work on identifying capacity need and possible ways to bridge these needs. Our main contact in Myanmar was University of Yangon, Department of Chemistry with pro-rector Dr. Kyaw Naing. NIVA visiting experts were research director Dr. Kristoffer Næs and research manager Mr. Mats Gunnar Walday.

A main activity was a seminar on marine water quality monitoring in Myanmar. The goals of the seminar were:
1) to educate Norwegian experts on how marine water quality monitoring is addressed in Myanmar
2) to present to scientific staff and students at the University of Yangon how relevant coastal zone managements issues are worked on in Norway, and to some extent also internationally.

Discussions with scientific staff at Yangon University, including BOBLME national coordinator Mr. Mya Than Tun, presentations of laboratory facilities at the university and presentations from Myanmar experts represent the knowledge base for identifying capacity needs.

1.4 Agenda for Myanmar visit

The agenda for the Norwegian visit was organized by Dr. Kyaw Naing in cooperation with the Norwegian experts, **Table 1**.

Table 1. Agenda for information and discussions under the Norwegian Institute for Water Research visit to University of Yangon, Chemical Department

Date	Agenda
Tuesday, 10.6.2014	• Meeting with Pro-Rectors • Tour at the University (Convention Hall, Universities Research Centre, Yangon University Library, Department of Chemistry) • Facts of University of Yangon • Introduction to Department of Chemistry • Introduction to Quality Assessment of Seawater in Myanmar Coastal Areas • Marine science in Myanmar • Discussions
Wednesday, 11.6.2014	• NIVA presentations on marine pollution and monitoring
Thursday, 12.6.2014	• Information on the BOBLME project • Presentation on mangrove research and protection by Myeik University • Discussions
Friday 14, 13.6.2014	• Discussions on capacity needs • Meeting with Norwegian Embassy

1.5 Main scientific contacts

Main Myanmar scientific contacts for presentations and discussions are given in **Table 2**

Table 2. Main scientific contacts

Contact	Affiliation
Professor Dr. Kyaw Naing	Pro-Rector University of Yangon; Director Asia Research Centre
Professor Dr. Anug Kyaw	Pro-Rector University of Yangon
Professor Dr. Pho Kaung	Pro-Rector University of Yangon
Professor Dr Ni Ni Than	Department of Chemistry, University of Yangon
Professor Dr. Ni Ni Sein	Department of Chemistry, University of Yangon
Professor Dr. Hnin Aye	Department of Chemistry, University of Yangon
Professor Dr. Aye Aye Myint	Department of Chemistry, University of Yangon
Professor Dr. Daw Hla Ngwe	Department of Chemistry, University of Yangon
Professor Dr. New Ni Khin	Department of Physics, University of Yangon
Professor Dr. Nang Mya Han	Department of Marine Science, Myeik University
Lecturer Dr. Myat Kyaw Thu	Department of Chemistry, University of Yangon
Lecturer Dr. Min Thein	Department of Chemistry, University of Yangon
Mr. Mya Than Tun	Deputy Director, Department of Fishery

2. Seminar on marine water quality monitoring in Myanmar

A seminar on marine pollution and monitoring issues most relevant for Myanmar was an important part of the visit, **Figure 1**.

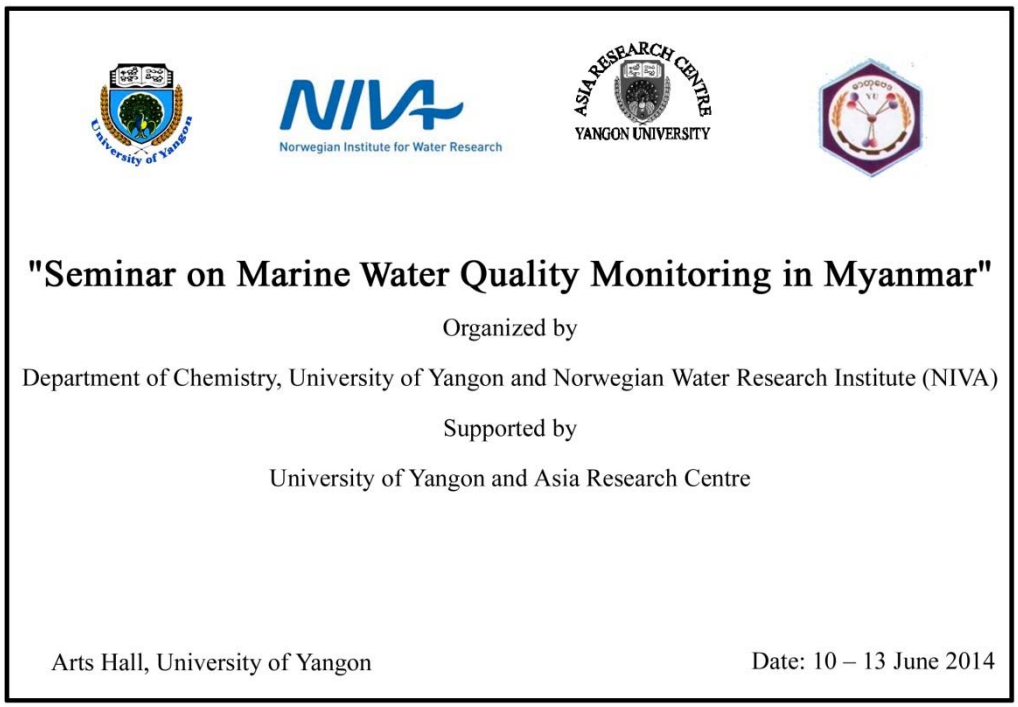

Figure 1. Invitation to seminar on marine water quality monitoring in Myanmar.

The thematic profile of the presentations was clearly linked to and in response to the main environmental issues in the Myanmar coastal zone as pointed out in chapter 1. The presentations are listed in **Table 3**. The seminar was headed by Professor Dr. Kyaw Naing and gathered 70-80 participants all together including scientific staff and students, **Figure 2**. Scientific staff represented numerous departments, i.e. Department of Chemistry, Department of Zoology, Department for Physics, Department for Economic geography, Department of Fisheries as well as Asia Research Centre.

Table 3. Myanmar and NIVA presentations at "Seminar on Marine Water Quality Monitoring in Myanmar".

		Topic	**Presenter**	**Additional scientific contact person**
Myanmar experts		Some facts of University of Yangon	Dr. Ni NI Than	
		Introduction to Department of Chemistry	Dr. Hnin Hnin Aye	
		Introduction to quality assessment of seawater in Myanmar coastal areas	Dr.Ni Ni Sein	
		Assessment of sea water quality of Myanmar deltaic coastal zone	Dr. Min Thein	
		Marine Science of Myanmar	Dr. Nan Mya Than	
		Information of the BOBLME project	Mr. Mya Than Tun	
Norwegian experts		General information about NIVA	Dr. Kristoffer Næs	
		Coastal monitoring –nutrients and organic load	Mr. Mats G. Walday	Dr. Kjell Magnus Norderhaug kjell.norderhaug@niva.no
		Monitoring of contaminants along the coast of Norway	Dr. Kristoffer Næs	Mr. Norman Green (norman.green@niva.no)
		New concept of organizing monitoring	Mr. Mats G. Walday	Dr. Are Pedersen are.pedersen@niva.no
		Litter, macro- and microplastics in marine ecosystems	Dr. Kristoffer Næs	Dr. Kevin Thomas/ Dr. Eva Ramirez Llodra (kevin.thomas@niva.no/ eva.llodra@niva.no)
		Pharmaceuticals in the environment	Dr. Kristoffer Næs	Dr. Kevin Thomas (kevin.thomas@niva.no)
		Eutrophication and climate change	Mr. Mats G. Walday	Dr. Kjell Magnus Norderhaug kjell.norderhaug@niva.no
		Remediation of contaminated sediments in Norway	Dr. Kristoffer Næs	Mr. Morten Schaanning (morten.schaanning@niva.no)
		Environmental challenges related to open sea cage aquaculture in coastal waters	Dr. Kristoffer Næs	Dr. Trine Dale (trine.dale@niva.no)

Figure 2. Seminar attendees.

The Myanmar presentations gave very important and interesting information on the coastal pollution, monitoring and management challenges for the country. Also the overview of the Bay of Bengal environmental situation and the BOBLME project given by Mr. Mya Than Tun was very informative as was the presentation on protection and restauration of the mangrove forest given by professor Dr. Nan Mya Han from the Myeik University. The main conclusion from these presentations is that increased focus and capacity building is necessary to have a sound management of coastal ecosystems. How to achieve this is further elaborated in chapter 3 and 4.

NIVA's presentations focused on generic environmental issues for coastal zone management and how they were addressed and solved in Norway. These pollution issues are also highly relevant for Myanmar coastal waters.

Based on discussions during the visit and presentations at the seminar, an initial priority list of capacity needs was formulated by Mr. Mya Than Tun and the scientific staff from Department of Chemistry attending the meetings, **Table 4**.

Table 4. Initial capacity needs identified and formulated by the attending scientific staff from Department of Chemistry and Mr. Tun. (Needs are linked to our suggested tasks in chapter 4 of this document)

	Need	**Comment**	**Chapter 4**
1	Training for staff and postgraduate students related to sea water research		Task 2
2	Development of analytical capabilities	Upgrade analytical research laboratory to national level	Task 4
3	New instrument	ICP-MS	Task 4
4	Chemicals	General use chemical for water analysis	Task 4
5	Support to meet objectives in the BOBLME project	• Habitat mapping • Establishment of an effective ecosystem indicator framework • Develop approach to identify and managing important coastal pollution issues	Tasks 1,2,3,5,6 and 7
6	Boat	Specified for water research issues	Task 4
7	Series of seminars	Information/training/mentoring academic staff and students	Tasks 1,2,3,4,5,6 and 7
8	Various instruments	BOD/COD measurement system, turbidity meter, ultrasonic cleaner, fluoride ion meter, water bath, tintometer, field equipment for coastal monitoring, arsenator, water/microbiological test kits, biological microscope, colony counter	Task 4

The needs are further discussed and detailed in chapters 3 and 4.

3. Marine water quality monitoring - Capacity needs

In the following paragraphs capacity needs are further discussed and finally a detailed process forward is suggested in chapter 4.

3.1 Information on the current situation in Myanmar

Our view on the marine water quality monitoring in Myanmar is described on the basis of the information we received during the visit to the University of Yangon in June 2014 and other information we have received through "Integrated Water Resources Management – Institutional Building and Training" under the Norwegian – Myanmar cooperation. Hence the conclusions in the following chapters are based on limited information. This should be acknowledged when extrapolating the conclusions to be valid national wise.

Pressure on the coastal zone in the Bay of Bengal is increasing. There are 400 million people living along the coast of the bay - most of them dependent on ecosystem services from marine areas. In addition to the anthropogenic impact in the region, large-scale climate changes increases uncertainty regarding the future development of the state of the coastal environment. The BOBLME-project defines habitat destruction as one of the main challenges in the coastal zone. Coral reefs, mangroves and sea grass beds are defined as the most important habitats along the coast. They are all exposed to an increased pressure.

The Department of Chemistry, University of Yangon have committed and skilled professionals. It seems that many of the scientists are quite specialized in their expertise and there are needs for courses and training within applied scientific work in the context of environmental assessments and developing marine monitoring programs.

Monitoring and mapping is done nationally, but seems to be non-systematic and randomly performed, regarding both the scientific design and subsequent use of the data collected. This contributes to the lack of knowledge on the over-all state of the environment along the coast. Necessary infrastructure for coastal monitoring seems to be poorly developed, lacking basic equipment both on a laboratory scale and for the field work situation, including no dedicated boats for monitoring and sampling along the coast.

Sectorial division and long decision-making lines appears to limit the cooperation between sectors that is required to achieve a sound and coordinated management of the coastal zone. Information sharing among different sectors needs to be improved. Regulation and environmental impact assessment of established and new activities in the coastal zone seem weak. To our information, requirements to perform environmental impact assessments for planned activities in the coastal zone of Myanmar are only to a certain degree developed. Consequently, there is a need to institutionalize effective and sound coastal water management. This means to develop regulations, guidelines, laws and new legislations for project impact analysis.

3.2 Capacity needs

Based on observations and discussions during our stay, capacity needs relate both to infrastructure and staff at the Department of Chemistry as such, but also national needs to address assessments, monitoring and remedial actions in the Myanmar coastal zone. From that perspective, capacity building is necessary on several levels:

1) Individual level
2) Institutional level
3) System level

We will focus on capacity building on individual and institutional level.

3.2.1 Laboratory

There is a strong need to strengthen and upgrade the laboratory capabilities at the Department of Chemistry. In the context of being able to perform marine pollution and water quality monitoring to international standards, laboratory facilities need far-reaching upgrading. This includes rebuilding the laboratories or alternatively a construction of new facilities, new hardware, chemicals and analytical instruments. Having an updated and equipped laboratory is a prerequisite for addressing assessment and monitoring work. In upgrading the laboratory, attention should also be given to personnel safety to avoid exposure to harmful substances.

3.2.2 Training and mentoring

Platforms for training and project collaboration for scientific staff should be developed. This should include mentoring and training related to analytical chemistry, monitoring methods, project management and multidisciplinary team-work. One way of fostering this could be through increased co-operation with NIVA. NIVA has more than 25 years of experience in designing, running and leading large national monitoring programs. Training of Myanmar staff could be done by training visits to NIVA in Norway, combined with seminars and practical training on site in Myanmar. Pilot projects in coastal areas might give opportunities for 'learning by doing'.

3.2.3 Analytical quality assurance

Quality of analytical results is important. The system for quality assurance of chemical analysis should be evaluated and eventually updated, for example through intercomparison exercises. Training and mentoring will also be an important task to assure high quality analytical work.

3.2.4 Framework for monitoring

Integrated Coastal Zone Management (ICZM) is required to effectively manage Myanmar's coastal waters resources in a coordinated manner. As part of this a scientifically based monitoring of the coast - based on feasible, cost-effective and robust methods, should be established. Regional water management plans based on watersheds are probably more understandable and engaging than larger national plans. A customized version of the European Water Framework Directive in line with the drafted National Water Framework Directive for Myanmar could be a suitable model to achieve holistic water monitoring with regional engagement. The framework directive is based on four main pillars (cf. EC 2014):
1) Coordinated action to achieve 'good status' for all waters, including surface and groundwater.
2) Setting up a water management system based on natural river basin districts, crossing regional and national boundaries.
3) Integrated water management, bringing different water management issues into one framework.
4) Active involvement of interested parties and consultation of the public.

3.2.5 Strategy for data collection and handling

As far as possible, data collection should be done according to international standards. The most relevant biological quality elements and supporting parameters for monitoring must be chosen – distribution, availability, cost, and their relevance as indicators on impact from stressors must all be considered. Sampling design is of certain importance, this includes overall principles involved with sampling efforts, including planning and sample design, quality assurance and quality control.

Chemical status of the coastal environment is generally defined in terms of compliance with quality standards for chemical substances in different matrix (water, biota, sediment). There are a number of quality standards established for chemical substances at European level and these should be considered for the Myanmar coastal environment. As far as we know, there is little baseline information on the chemical status in Myanmar waters and thus, screening for micro pollutants in the coastal environment might be necessary.

Existing infrastructure as platform for monitoring should be evaluated. The total length of the coastline of Myanmar is almost 2000km and there is need for cost-effective monitoring methods. Satellite based systems can provide extensive coverage of the sea surface in a short time and has therefore become important sensors for operational monitoring of the marine environment. Commercial vessels make regular transits along the coast and on the ocean and may offer an excellent opportunity to collect important scientific data. This concept is known as 'Ships of opportunity' (SOOP). Data collection from commercial vessels will allow increased coverage, frequency, repeatability, duration, and convenience compared to traditional research vessels. The figure below shows an example from NIVAs database system called Ferrybox. Ferrybox collects monitoring data from commercial vessels in Norway.

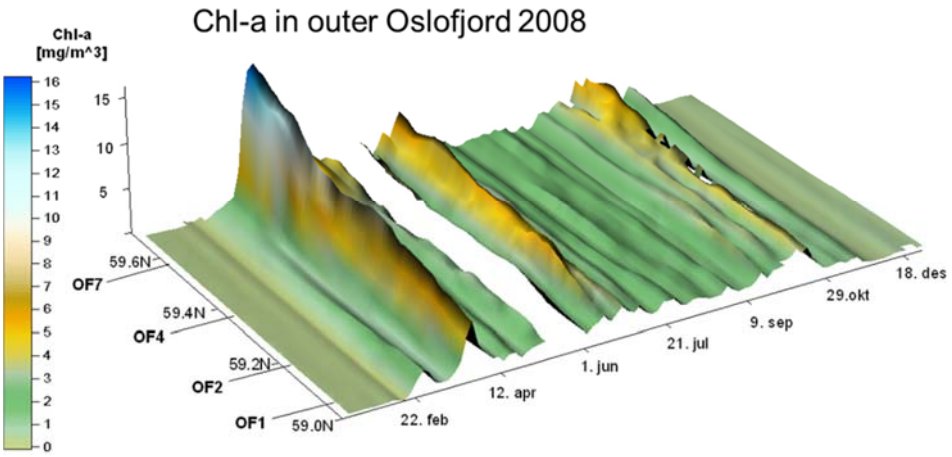

Figure 3. Ferrybox-sampling, based on the principle of SOOP, gives data with high temporal and spatial resolution. Example from the monitoring of chlorophyll-a in outer Oslofjord in Norway.

Practical fieldwork tasks is recommended to be carried out in a pilot project setting, also including on-the-job training for water type characterisation, classification of environmental status, setting environmental goals, mitigating measure analysis, water management plans, etc.

During our visit in Myanmar our impression was that it is necessary to strengthen the management of the existing marine protected areas in Myanmar. It may also be necessary to create additional protected areas. MPAs are important refugees for the marine life, and as so also functioning as reference areas for the assessment of status of the non-protected areas.

By combining data on species/habitat distribution and biodiversity indices with information on environmental conditions, human impacts and other stressors, the relationships between the biology, the surrounding environment and human activities may be assessed. If information is made available as full-coverage maps in geographic information systems (GIS), these relationships may be developed into spatial maps that may be used in spatial management and planning, including in coastal zone plans and the work with marine protected areas.

3.2.6 Public communication

It must be developed a plan for dissemination of results and other information from the monitoring activities. Active involvement of interested parties and consultation of the public assume that information on activities and results are available to the public in an appealing form.

4. Suggested progress

A progress forward is suggested through 8 interconnected tasks spanning from defining framework, through mentoring to actual pilot studies. One of the tasks is related to upgrading/rebuilding the laboratory facilities at the Department of Chemistry, University of Yangon to be able to perform marine pollution and water quality monitoring in compliance with international standards. We recognize that the Asian Research Centre at the University of Yangon has advanced equipment and also that a national water quality laboratory is to be developed at MOECAF under the Norwegian – Myanmar cooperation (Water Resources Management Program – freshwater project). It should in a later stage be discussed if upgrading of marine and freshwater quality laboratories should be coordinated. In this report the assumption is to establish a marine water laboratory at the Department of Chemistry.

Task 1: Inception phase

No.	Activity	Description of activity	Deliverable
1.1	Establishment of Program Management Group (PMG)	Names, affiliation and responsibilities. Coordinate with and include BOBLME	
1.2	Mapping of the national capacities	Broaden capacity need assessment by visiting other relevant ICZM structures	
1.3	Establishment of programme anchoring on ministerial level	Names, affiliation and responsibilities from both Myanmar and Norway side.	
1.4	Establish ownership to programme outputs and activities among all programme participants	Secure information flow and exchange of knowledge between the partners and between the different tasks.	
1.5	Select case study area	A relevant case study area for Task 6 should be selected early in the project and is hence presented as a task for the Inception phase	
1.6	Inception report	Including project description and activity plan	Report

Task 2: Integrated Coastal Zone Management (ICZM)

No.	Activity	Description of activity	Deliverable
2.1	Study and review current relevant policies, regulations and legislations	Overview and short analysis of IWRM relevant policies, regulations and legislations in Myanmar	
2.2	Review present international approaches to ICZM	Includes an overview of main approaches to ICZM	
2.3	Propose key elements for Myanmar ICZM based on national knowledge and international experiences	Includes a proposal for key elements, or principles which are relevant for the Myanmar ICZM framework based on the two above activities.	Part of task 2 report
2.4	Provide input to the National Water Resources Committee and their Expert Group	Report based on the above activities	Part of task 2 report
2.5	Theoretical training courses in ICZM	Introduction to the EU Water Framework and to Myanmar National Water Framework Directive. Stakeholder involvement and capacity building Monitoring of water quality Surveillance systems as ICZM tools Capacity building on lab quality assurance and analysis Data-base requirements for storing and utilizing monitoring data	Training material
2.6	Practical training courses in ICZM	Fieldwork and laboratory analyses for characterization of ecological status. This activity should be done in connection to Task 4, phase 1 and 2. One assumption for activity 2.6 is that a well-equipped boat has been established for this purpose.	Training material

Task 3: Water Quality Criteria

No.	Activity	Description of activity	Deliverable
3.1	Identify categories of coastal water use in Myanmar, water quality requirements and water body types	Literature review, data request from relevant ministries, field studies and stake holder consultation.	Report
3.2	Identify coastal water quality classification limits	Inter-calibration exercises Specific training during field work	
3.3	Identify biological quality elements appropriate for assessing the ecological status of Myanmar water	Literature review on dose-response on relevant impact for the selected biological quality elements, identify gaps of knowledge	
3.4	Use the physical-chemical and biological results to adjust the water quality criteria.		
3.5	Training and competence building in Water Quality criteria and ecological status.	Use of identified key water quality criteria, establish procedures and prepare manuals	Training material Procedures and manuals

Task 4: National Water Quality Laboratory

Task 4 is suggested under the assumption that a national laboratory for marine monitoring should be part of Department of Chemistry, University of Yangon. Discussion should though be held on cooperation between this laboratory, the laboratory at the Asian Research Centre and the national water quality laboratory to be developed under the Norwegian-Myanmar agreement (Integrated Water Resources Management – Institutional Building and TrainingProgram).

Task 4 will be divided into two phases to ensure a good end result. Phase 1 will include upgrading of laboratory building and facilities, upgrading or purchasing a well-equipped boat, and training in the use of field equipment. Phase 2 will include new laboratory equipment and training in laboratory work.

	No.	Activity	Description of activity	Deliverable
Phase 1	4.1	Specification of technical needs including field equipment and boat	Specification of technical needs regarding water quality laboratory areas, as building facilities, power supply, ventilation needs field equipment, boat and other equipment, HSE requirements.	Technical report (including laboratory, boat and field equipment)
	4.2	Technical installations and upgrading of existing laboratory	Procurement of technical equipment and installation/rehabilitation of the existing laboratory.	
	4.3	Procurement and installation of laboratory equipment	General glassware, filtration equipment, general laboratory equipment, balance, water distillation unit, field kits and field instruments	
	4.4	Training and competence building (Field)	Analytical methods, quality assurance, maintenance, dissemination of analytical results, HSE.	Training material
Phase 2	4.5	Specification of laboratory equipment	Specification for stationary laboratory instruments	Specification
	4.6	Procurement and installation of laboratory equipment		
	4.7	Procurement and installation of computer system and network	Installation of computers for both instruments and lab data management systems. This should be done in cooperation with Task 7, Database system	
	4.8	Training and competence building (Laboratory)	Training sessions and courses in laboratory management, quality assurance and HSE Analytical methods, quality assurance, maintenance, dissemination of analytical result.	Training material

Task 5: Myanmar National Water Framework Directive

No.	Activity	Description of activity	Deliverable
5.1	Study the Myanmar water legislation in light of the EU WFD, to identify possible needs for adjustments either in the laws or in the Myanmar NWFD.	Produce an overview of institutions and laws in Myanmar; Signed International conventions; General Challenges; Needs for adjustments.	Task 5 Report
5.2	Identify the current administrative units, and sector authorities involved in coastal water management.	A written description / profile of the water management administrative units, including information of their responsibilities, and their ministerial affiliation.	Task 5 Report
5.3	Identify public and stakeholder involvement	Involvement: of both the general public and of stakeholders	Task 5 Report

Task 6: Case study - Water management Plan

No.	Activity	Description of activity	Deliverable
6.1	Identify case study area	This activity is also included in Task 1 (Inception phase)	
6.2	Characterisation	Collecting base line data. Identification of water bodies, water type designation, identify candidates for heavily modified water bodies, water use analysis, pressure analysis, risk assessment. Prioritize among water management issues	
6.3	Monitoring	Design sampling program. Monitoring of water quality and ecological quality in the selected case study areas.	
6.4	Data management	Data management of monitoring data	Data management plan for case study area
6.5	Environmental goal setting and classification of water quality and ecological status	The goal setting will consider the different sector user needs, including civil society. Deciding a feasible, a realistic goal which balance the different user needs will involve dialogue with main stakeholders (water quality, water depth and the impact on ecosystem services). Classify the water bodies according to water user criteria and the ecological classification scheme.	
6.6	Abatement measure analysis and abatement programme.	List of all relevant measures for reaching the environmental goals, rank measures according to cost efficiency, prioritizing among abatement measures	
6.7	Public and stakeholder involvement on relevant stages	Specifying a proposal on how and when and who will be involved.	
6.8	Water management plan	Water management plan for this case study area.	Report

Task 7: Database system

No.	Activity	Description of activity	Deliverable
7.1	Tailoring of database system to meet Myanmar coastal water needs.	Determining data base system and prepare the database to meet Myanmar coastal water needs Collect and import available historical data Collect and import GIS maps and if possible images	Specification
7.2	Specify and purchase technical equipment	Specify and purchase technical equipment that is needed. Identify server location and installation of hardware and software.	
7.3	Defining data management plans and routines	Defining plans and routines	Report including plans and routines
7.4	Testing, preparing amendments and updating the database	Define and specify new needs and amendments according to Myanmar coastal water needs. Implement Myanmar water quality classification procedures in this database system	Specifications
7.5	Training and competence building in coastal zone manage	Training and competence building in coastal zone management and in the use of this database system as a tool for coastal zone management.	Training material
7.6	Training and competence building in technical issues regarding database	Training and competence building in technical issues regarding this database system	Training material

Task 8: Management and administration

No.	Activity	Description of activity	Deliverable
8.1	Programme coordination and management throughout the programme	Keeping an overview for the whole project and secure progress according to plans	Progress reports
8.2	Coordination with other programmes and projects, e.g. BOBLME.	Exchange and seek information from other institutions and main responsible persons at cooperating institutions both in Norway and abroad.	
8.3	Annual programme management meetings	Its main tasks are communicating project output, monitoring progress, and evaluating and updating the work plan.	Minutes from meetings
8.4	Public and stakeholder involvement on relevant stages	Responsible for relevant public and stakeholder involvement throughout the project	
8.5	Preparation of annual reports	Annual reports will be prepared for annual consultation meetings	Annual reports
8.6	Final programme report	Technical and administrative reports with main results, including main results from each output	Final report
8.7	Final programme seminar	Final programme seminar to present main project results Invite all stakeholders that have been involved in the project.	Minute from seminar

5. Bridging capacity needs

An agreement has been reached and will shortly be signed between Myanmar and Norway, between the Ministry of Environmental Conservation and Forestry (MoECaF) and the Norwegian Embassy in Yangon, on environmental cooperation. The "Integrated Water Resources Management – Institutional Building and Training" of this programme focuses on future cooperative activities that can assist Myanmar in establishing efficient Integrated Water Resources Management (IWRM) approaches. Presently, a three year programme (2015 – 2017) is under development and consists of four groups of activities:

- **Integrated Water Resources Management (IWRM) in the Sittaung River and the Bago River:** Based on the drafted Myanmar National Water Framework Directive (MNWFD) make adjustments and application of the European EU Water Framework Directive on common Water Policy (WFD) in the context of conditions in Myanmar. The Sittaung River Basin was chosen as a case study site for identifying how the WFD could be applied within the Myanmar administrative system. Practical WFD work tasks should be carried out in a small river (the Bago River, a neighbouring river to the Sittaung River); including on-the-job training for practical water management (characterisation, monitoring, classification, setting environmental goals, mitigating measure analysis, water management plan, etc.)

- **Monitoring activities in Inlay Lake**; water quality, aquatic vegetation, phytoplankton, sedimentation, loss of free lake surface, etc. This will provide opportunities for on-the-job training in WFD lake-monitoring concepts. A database is necessary to store and manage the monitoring data and appurtenant information, and should be developed to fulfil Myanmar's needs.

- **IWRM tools**; develop recommendations and provide input to the drafted National Water Framework Directive, the National Water Policy and Water Quality Guidelines for general ecological status. Support preparations for a review ofwater use needs, and for stakeholder involvement in the development of the water management plan. A database to manage data is also a key tool in IWRM.

- **Establish a national water quality laboratory**. Upgrade and modernise the laboratory at MOECAF and train personnel. Firstly establish methods for general water quality, then prepare for the establishment of methods for heavy metals and organic micro-pollutants which are expected to be included as part of a next period of cooperation between Myanmar and Norway on environmental issues and IWRM.

In our view, bridging capacity needs related to integrated coastal zone management in Myanmar can benefit substantially on close cooperation with the just started Integrated Water Resources Management programme. The Norwegian Embassy in Yangon plays an important role in developing this programme. Possible extention of the fresh water project to the marine environment was therefore one of the discussions we had during our meeting with first secretary Marte Briseid at the Norwegian Embassy in Yangon. The Norwegian involvement presently focuses on fresh water issues. However, the possibilities of addressing the capacity needs outlined above in cooperation with the "Integrated Water Resources Management – Institutional Building and TrainingProject" under Norwegian – Myanmar agreement to be signed shortly would be strongly beneficial scientifically and probably also economically.

The Norwegian Embassy in Yangon pointed out the Norwegian Agency for Development Cooperation (NORAD) for discussions on the possibilities to address coastal zone issues under the Bay of Bengal Large Marine Ecosystem project. To that end, NORAD senior advisor Helle Biseth informed that Myanmar is prioritized and plans are under development. Focus areas to be included will also depend on

financial priorities made by the Norwegian Government. The conclusion from the contact with senior advisor Helle Biseth is that we will continue to update NORAD for the purpose of seeking possibilities for addressing capacity needs and cooperation between Norway and Myanmar on coastal zone management.

Norway has since 2005 established the so-called "Oil for development" program. The objective is to facilitate economically, socially and environmentally responsible management of petroleum resources. Through this program Norway assists cooperating countries with capacity building within, among others, resource and environmental management. The "Oil for development" program is a cooperation between the Ministry of Foreign Affairs, Ministry of Petroleum and Energy, Ministry of Finance, and Ministry of Climate and Environment. The Norwegian Environment Agency (NEA) has a central position within the programme. In discussions with chief engineer Kristin Eine we were informed that "Oil for development" plans relevant for Myanmar will be worked on the coming year and that plans to address capacity needs as outlined above could be discussed when the program was more developed.

Institute for Marine Research (IMR) at Bergen, Norway, has for many years run projects on monitoring fishery resources in developing countries under the so-called "Nansen program". The program, financed by NORAD and FAO, has included cruises to the Bay of Bengal under the Bay of Bengal Large Marine Ecosystem project, last in 2013. IMR has applied to Norwegian officials for continuing work in the area. NIVA has institutional cooperation agreements with IMR and we have shared information on the two institute's activity in Myanmar/Bay of Bengal. This could open for future cooperation regarding coastal zone issues. The contact will be followed up, in particular related to the "Oil for development" program, in order to make effort for future work in Myanmar.

6. Conclusions

The following overall conclusions can be drawn from the discussions regarding needs for performing marine water quality monitoring in Myanmar:

- There are significant capacity needs in order to perform coastal zone management activities within international standards
- Capacity needs include development of framework for integrated coastal zone management, training and mentoring, laboratory upgrading and including instrumentations and infrastructure/equipment for field work (availability of boats)
- Capacity development must include and be coordinated with BOBLME objectives
- Bridging capacity needs can benefit substantially if coordinated f. ex. with the just started "Integrated Water Resources Management – Institutional Building and Training Project" under the Norwegian – Myanmar cooperation
- Bridging capacity need is dependent on financial support. This has to be developed i.a. under the Norwegian – Myanmar environmental cooperation.
- Contact with Norwegian officials will be continued in order to establish cooperative programs within marine water quality monitoring in Myanmar

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