Marine Conservation *in* Myanmar

Current knowledge and research recommendations

Marine Conservation *in* Myanmar

Current knowledge and research recommendations

Myanmar Ministry of
Livestock and Fisheries

Wildlife Conservation Society
Myanmar

Myanmar Marine
Science Association

The Blue Moon Fund

AUTHORS
Katherine E. Holmes, U Tint Tun, U Kyaw Thinn Latt, Mukesh Subedee, Supriya V. Khadke, Andrew E. Hostetler

MAJOR CONTRIBUTORS
U Aung Aung Aye, Isabel van Haag, Daw Lucy Chit, Daw Moe Moe Myint, U Soe Tint Aung, U Thaung Htut, Daw Theingi Lay, Dr. Tint Swe, U Tint Wai, Robert Tizard

DESIGN AND LAYOUT
Ramacandra Wong

Printed copies are available upon request to:
WCS Myanmar
Aye Yeik Mon 1st St., Ward 3, Building C1
Hlaing Township 11051
Yangon
Myanmar

Email: wcsmyanmar@wcs.org
Phone: +95 1 524893
Web: http://myanmar.wcs.org
Twitter: @WCSMyanmar

Citation: Holmes, K.E., Tint Tun, Kyaw Thinn Latt, M. Subedee, S.V. Khadke, and A.E. Hostetler. 2014. Marine Conservation in Myanmar - The current knowledge of marine systems and recommendations for research and conservation. Yangon, WCS and MSAM. 198 pp.

TABLE OF CONTENTS

INDEX OF APPENDICES

ACKNOWLEDGEMENTS

We are grateful for the support and permissions of U Ohn Myint (Minister, Ministry of Livestock, Fisheries and Rural Development), U Khin Maung Aye (Deputy Minister, Ministry of Livestock, Fisheries and Rural Development), U Khin Maung Maw (Director General, Department of Fisheries) and U Myat Ko (Chief Minister, Taninthayi Region).

Many people from the Chaung Tha, Thandwe and Myeik areas of Myanmar and from Ranong in Thailand shared their unique perspectives and knowledge of the marine world with us. We would like to thank those fishermen, fish processors, artisans, restaurateurs, hotel owners, tourism operators and tourists for their time and insights.

University academics and students welcomed us into their departments, allowed us access to their libraries, shared their research findings with us and, in many cases, joined our field team. Government and non-governmental organisation (NGO) employees met with us and contributed to our workshop discussions, sharing their perspectives. In particular, we would like to acknowledge the contributions of:

U Aung Aung (Ngapali Water Sport Center)
Dr. Rachel Graham (MarAlliance)
U Hla Win (National Advisory Board)
Dr. Htay Aung (Professor, Pathein University)
Dr. Htay Aung (Rector, University of Mawlamyine)
Dr. Khin Maung Cho (Head of the Marine Sciences Department, Pathein University)
Dr. Khin Maung Swe (Head, Department of Zoology, Dagon University)
U Khin Ko Lay (Retired, Director General, Ministry of Livestock and Fisheries)
U Ko Cho (Boat Captain)
U Maung Maung Kyi (RCA)
Dr. Maung Maung Gyi (Head, Department of Zoology, Yangon University)
U Maung Maung Thein Pe (Rakhita)
U Maung Maung Yi (Head, Department of Fisheries, Myeik District)
U Mya Than Tun (Deputy Director, Department of Fisheries)
Dr. Myint Myint Cho (Professor, University of Mawlamyine)
Dr. Nang Mya Han (Head, Marine Science Department, Myeik University)
Dr. San San Aye (Lecturer, Department of Zoology, University of Dawei)
Dr. San Thar Tun (Marine Science Department, University of Myeik)
U Saw Min Aung (Assistant Officer, Thandwe District Department of Fisheries)
Mr. Brian D. Smith (WCS)
Star High Company (Boat contribution)
Dr. Ranil Senanayake (Worldview Myanmar)
U Soe Htun (Head, Marine Science Department, University of Mawlamyine)
Dr. Swe Thwin (Retired professor, University of Mawlamyine)
U Tint Swe (Project Director, TNRP, Forest Department)
U Wanna (Boat Captain) and his crew
U Zau Lunn (FFI)

This review was made possible through the generous support of the Blue Moon Fund.

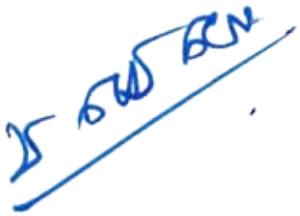
FOREWORD

Tremendous marine resources bless Myanmar and these resources have benefited our Union since ancient times. Unfortunately these resources are coming under increasing pressures. We know that the sustainable use of our marine resources will enable our people to continue to benefit from our seas, beaches, mudflats and mangroves.

As we are reminded in this report we know a great deal about our marine environment. There is a rich history of marine research through our Department of Fisheries and our marine science university programs. Bringing this information together in one place provides a strong foundation for our future actions to build upon. It is also clear that there is still much more work to do.

The future wealth of many of our citizens will be closely tied to our use of marine resources. As this report shows there is a very wide range of habitats, species, and products that will need to be conserved so that future generations can still benefit from this great wealth. Some of these products can be managed for long term use while others, such as Sharks and Rays have already been over used and must now be protected to ensure our marine ecosystem remains intact.

It is the responsibility of all citizens to work towards conserving the country's resources. We need to try new approaches including marine protected areas managed with local communities as well as working with the Myanmar Fisheries Federation to manage our fish stocks to sustain our fishing industry. I now look to the future for carefully planned development and conservation to be supported by the Government and our international partners to ensure that we benefit from our marine riches long into the future.



U Khin Maung Aye
Union Deputy Minister
Ministry of Livestock, Fisheries and Rural Development
Republic of the Union of Myanmar

FOREWORD

For over twenty years the Wildlife Conservation Society has supported the conservation of Myanmar's rich natural resources. Over these years much of our work has focused on forests and the people who use forests for their livelihoods and up until now our work in the marine realm has been relatively limited. In the past we have focused on studying and conserving the whales and dolphins of Myanmar's coastal waters and along the Ayeyawady River.

This report begins a new chapter for WCS's cooperative relationship with the Myanmar government, especially the Ministry of Livestock, Fisheries and Rural Development and the Department of Fisheries.

Myanmar's vast marine resources are an integral part of Myanmar's future development. Our country is already heavily dependent on fish and other marine products for our daily livelihoods as well as for lucrative export markets. The stunning beauty of our islands, beaches and coral reefs is rapidly becoming the basis of a growing tourism industry that will provide thousands of new jobs; while healthy coastal habitats such as mangroves and mudflats continue to protect us from natural disasters and the rising risks of climate change.

Unfortunately, many of the resources that have supported coastal communities and industries for generations are no longer sufficient to meet the country's needs. Now is the time for a dramatic shift in how these resources are utilized. We must find new opportunities to conserve and improve the management of these important resources before they are lost to all. I hope this report finds a wide audience and will serve as one step on the road to a better future for Myanmar.

U Than Myint
Country Program Director
Wildlife Conservation Society
Myanmar Program

အကျဉ်းချုပ်

ပြည်ထောင်စုသမ္မတမြန်မာနိုင်ငံတော်သည် ရှည်လျားသည့် ပင်လယ်ကမ်းရိုးတန်းများနှင့်အတူ အဏ္ဏဝါ အရင်းအမြစ်များ ပေါကြွယ်ဝစွာ ပိုင်ဆိုင်ထားခြင်းမှာ အလွန်ကံကောင်းပါသည်။ ယခင်က ကမ္ဘာ့အထီးကျန် နိုင်ငံဖြစ်ခဲ့ရာမှ ယခုအခါ ဒီမိုကရေစီနိုင်ငံအဖြစ်သို့ အသွင်ကူးပြောင်းနေ၍ နိုင်ငံတကာမှ ရင်းနှီးမြှုပ်နှံမှုများလည်း တဖြည်းဖြည်း တိုးတက်လျက်ရှိပါသည်။ အဆိုပါ ပြောင်းလဲမှုများကြောင့် အဏ္ဏဝါအရင်းအမြစ်များအား ပိုမိုထုတ်ယူ သုံးစွဲလာနိုင်သည့် အလားအလာများ ပိုမိုမြင့်မားလာနိုင်သကဲ့သို့ နိုင်ငံတကာ၏ အကူအညီများဖြင့် ထိန်းသိမ်းကာကွယ်ရေးလုပ်ငန်းများ၊ သုတေသနလုပ်ငန်းများနှင့် ထိန်းသိမ်းရေးဥပဒေပြုလုပ်ငန်းများကို ပိုမိုအရှိန်မြှင့် ဆောင်ရွက်လာနိုင်မည့် အခွင့်အလမ်းများလည်း ရှိနေပါသည်။

နိုင်ငံတော်အစိုးရဌာနများ၊ တက္ကသိုလ်နှင့် သုတေသနဌာနများနှင့် အစိုးရမဟုတ်သည့် အဖွဲ့ အစည်းများသည် အဏ္ဏဝါဇီဝမျိုးစုံမျိုးကွဲများနှင့် ယင်းတို့၏နေရင်းဒေသများအကြောင်း လေ့လာ ဆန်းစစ်မှုများကို ကျယ်ကျယ်ပြန့်ပြန့် ဆောင်ရွက်ခဲ့ကြပါသည်။ အဆိုပါလေ့လာတွေ့ရှိချက်များ၏ အချို့တစ်စိတ်တစ်ပိုင်းကိုသာ နိုင်ငံတကာအဖွဲ့အစည်းများမှတဆင့် ဒေသတွင်းနှင့် နိုင်ငံတကာ အစည်းအဝေးများတွင် ကျယ်ကျယ်ပြန့်ပြန့် တင်ပြခဲ့ကြပါသည်။ သို့သော် အဏ္ဏဝါသိပ္ပံဆိုင်ရာ လေ့လာမှုအများစုမှာ ပုံနှိပ်ထုတ်ဝေနိုင်ခဲ့ခြင်းမရှိ၍ အဆိုပါသတင်းအချက်အလက်များကို ရှာဖွေ ရယူရန် မလွယ်ကူပါ။ မြန်မာ့ပင်လယ်ပြင်ရှိ အဏ္ဏဝါမျိုးစိတ်များနှင့် ယင်းတို့၏ နေရင်းဒေသ အခြေအနေများကို လေ့လာဆန်းစစ်မှု အနည်းငယ်သာ ဆောင်ရွက်နိုင်ခဲ့ပါသေးသည်။

မြန်မာနိုင်ငံ၏ အဏ္ဏဝါသယံဇာတများ၏ လက်ရှိအခြေအနေများကို နားလည်သိရှိနိုင်ရန်နှင့် အနာဂတ်တွင် ဆောင်ရွက်နိုင်မည့် အဏ္ဏဝါဆိုင်ရာ ထိန်းသိမ်းရေးလုပ်ငန်းများအတွက် အခြေခံ အုတ်မြစ်ချမှတ်နိုင်ရန် အဏ္ဏဝါဇီဝမျိုးစုံမျိုးကွဲများနှင့် နေရင်းဒေသများကို လေ့လာမှုပြုလုပ် ထားသည့် စာတမ်း (၆၀၀) ကိုစုဆောင်းခဲ့ပါသည်။ အဏ္ဏဝါနေရင်းဒေသများအတွက် ရရှိနိုင်သည့် ပထဝီဝင်သတင်းအချက်အလက်မ ျားကိုလည်း စုဆောင်းရယူခဲ့ပါသည်။ အသစ်ရရှိသည့် ဂြိုလ်တု သတင်းအချက်အလက်များကိုအခြေခံကာ ထိန်းသိမ်းရေးအတွက် အထူးအရေးပါသည့် အဏ္ဏဝါ နေရင်းဒေသနှစ်ခု၏ ပျံ့နှံ့မှုအခြေပြမြေပုံများကို ပြုစုခဲ့ပါသည်။ ဖော်ပြပါ အရင်းအမြစ်များမှ သတင်း အချက်အလက်များနှင့် တွေ့ရှိချက်များကို ယခုအစီရင်ခံစာတွင် အကျဉ်းချုပ်ကာ ဖော်ပြထား ပါသည်။

အဏ္ဏဝါပတ်ဝန်းကျင် ထိန်းသိမ်းရေးဆိုင်ရာ ဥပဒေစနစ်များကို ပြန်လည်သုံးသပ်ထားပြီး အဓိက ပါဝင်ဆက်နွယ်သူများကို အကျဉ်းချုပ်ဖော်ပြထားပါသည်။ အဏ္ဏဝါဆိုင်ရာ ထိန်းသိမ်းရေးနှင့် သုတေသနလုပ်ငန်းများကို ဦးစားပေးရွေးချယ်နိုင်ရန် ပါဝင်ဆက်နွယ်သူများအားလုံးကို ဖိတ်ကြား ကာ အလုပ်ရုံဆွေးနွေးပွဲ တစ်ခုကို ကျင်းပခဲ့ပါသည်။ ထို့အပြင် ရခိုင်နှင့်တနင်္သာရီ အဏ္ဏဝါ ဆက်စပ်ဇရိယာနှစ်ခုကို ဦးစားပေး ထိန်းသိမ်းရေး ဆက်စပ်ဇရိယာများအဖြစ် ဖော်ပြထားပါသည်။

ရရှိလာသည့် ကွဲပြားစုံလင်သော သတင်းအချက်အလက်များအပေါ် အခြေခံကာ မြန်မာနိုင်ငံ၏ အဏ္ဏဝါဆိုင်ရာ ထိန်းသိမ်းရေးအတွက် အနာဂတ်လုပ်ငန်းစဉ်များတွင် ထည့်သွင်းစဉ်းစားသင့်သည့် အချက်များကို အကြံပြု တင်ပြထားပါသည်။

မြန်မာနိုင်ငံ၏ အဏ္ဏဝါဆိုင်ရာ ထိန်းသိမ်းရေးလုပ်ငန်းများကို အမြင်ချင်းဖလှယ်ခြင်း၊ စဉ်းစား ဆင်ခြင်ခြင်းနှင့် စီမံချက်များ ပူးပေါင်းရေးဆွဲခြင်းတို့ဖြင့် အဏ္ဏဝါအရင်းအမြစ်များကို ထိရောက်စွာ စီမံခန့်ခွဲ ထိန်းသိမ်းနိုင်ကြမည် ဖြစ်ပါသည်။ ယင်း၏အကျိုးဆက်များမှာ မြန်မာနိုင်ငံ လုပ်သား ပြည်သူများ၏ လူနေမှုဘဝများ၊ စီးပွားရေးနှင့် ကျန်းမာရေးများအတွက် စဉ်ဆက်မပြတ် အထောက်အပံ့များအဖြစ် တည်ရှိနေမည် ဖြစ်ပါသည်။

EXECUTIVE SUMMARY

The Republic of the Union of Myanmar is fortunate to have a long coastline that supports rich marine communities. The country is undergoing a rapid transition from one of the world's most isolated countries to an emerging democracy allowing for increased international investment. This change may bring increased demands on marine resources along with opportunities for improved conservation, research and legislation measures through international co-operations.

Myanmar's government departments, academics and NGOs have conducted numerous studies on a wide range of the country's marine resources and habitats. Subsets of this information have been presented at regional and international meetings and are shared more broadly through international organisations. However, many studies of Myanmar's marine life have never been published and remain difficult to access. And few assessments have been conducted to determine the status of marine species and habitats.

To understand the current state of marine resources in Myanmar and to lay a foundation for future marine conservation activities, we complied over 600 papers and reports relating to the country's marine biodiversity and habitats. We also gathered existing GIS data on marine habitats and generated distribution maps for two critical marine habitats based on newly available satellite datasets. Information and findings from these sources are summarized in this report.

We provide a summary of stakeholders and review the legal structures that relate to the marine environment. We conducted a stakeholder workshop to identify priorities for research and conservation activities. We also describe the two marine priority "Conservation Corridors", namely the Rakhine and Taninthayi Marine Corridors.

From this diverse set of information, we have generated recommendations for future marine conservation activities in Myanmar.

Through informed, thoughtful and coordinated planning, marine resources in Myanmar may be effectively managed and conserved in order to continue to support the livelihoods, economy and health of the people of Myanmar.

ACRONYMS

ADPC	Asian Disaster Preparedness Center
APFIC	Asia-Pacific Fishery Commission
ASEAN	Association of Southeast Asian Nations
BANCA	Biodiversity and Nature Conservation Association
BOBLME	Bay of Bengal Large Marine Ecosystem
CBD	Convention on Biological Diversity
CBNRM	Community-Based Natural Resource Management
CIT	Community Involvement in Tourism
CITES	Convention on International Trade in Endangered Species of Wild Fauna and Flora
CoL	Catalogue of Life
CR	Critically Endangered
CTA	Classification Tree Analysis
DD	Data Deficient (IUCN Red List Category)
DEC	Department of Environmental Conservation
DoF	Department of Fisheries
ECoSwiss	Europe Conservation Switzerland
EEZ	Exclusive Economic Zone
EIA	Environmental Impact Assessment
EN	Endangered (IUCN Red List Category)
FAO	Food and Agriculture Organization of the United Nations
FD	Forest Department
FREDA	Forest Resource Environment Development and Conservation Association
FFI	Fauna and Flora International
GA	General Administration
HIA	Health Impact Assessment
IOSEA	Indian Ocean and South-East Asian region
INGO	International Non-Governmental Organization
ITIS	Integrated Taxonomic Information System
IUCN	International Union for the Conservation of Nature
IUU	Illegal, Unreported and Unregulated (fishing)
JICA	Japan International Cooperation Agency
KBA	Key Biodiversity Area
LC	Least Concern (IUCN Red List Category)
LIFT	Livelihoods and Food Security Trust Fund
LNGO	Local Non-Governmental Organization
MBCIV	Myanmar Biodiversity Conservation Investment Vision
MEI	Myanmar Environment Institute
MERN	Myanmar Environment Rehabilitation-conservation Network
MFF	Mangroves for the Future
MFF	Myanmar Fishery Federation
MPA	Marine Protected Area
MSAM	Marine Science Association, Myanmar
MAPDRR	Myanmar Action Plan for Disaster Risk Reduction
MoE	Ministry of Education
MoU	Memorandum of Understanding
MOECAF	Ministry of Environmental Conservation and Forestry
MoHT	Ministry of Hotels and Tourism
MLFRD	Ministry of Livestock, Fisheries and Rural Development
NBSAP	National Biodiversity Strategy and Action Plan
NGO	Non-Governmental Organization
NOAA	National Oceanic and Atmosphere Administration
NPOA	National Plan of Action
NT	Near Threatened (IUCN Red List Category)
NWCD	Nature and Wildlife Conservation Division
OBIS	Ocean Biogeographic Information System (OBIS)
OLI	Operational Land Imagery
PADI	Professional Association of Diving Instructors
RCA	Rakhine Coastal Region Conservation Association
SEAFDEC	Southeast Asian Fisheries Development Center
SIA	Social Impact Assessment
SMA	Special Management Area
TED	Turtle Excluder Device
UNEP	United Nations Environment Programme
UNDP	United Nations Development Programme
USD	United States Dollar
VCP	Village Consultation Process
VU	Vulnerable (IUCN Red List Category)
WoRMS	World Register of Marine Species
WCS	Wildlife Conservation Society
WS	Wildlife Sanctuary

INTRODUCTION

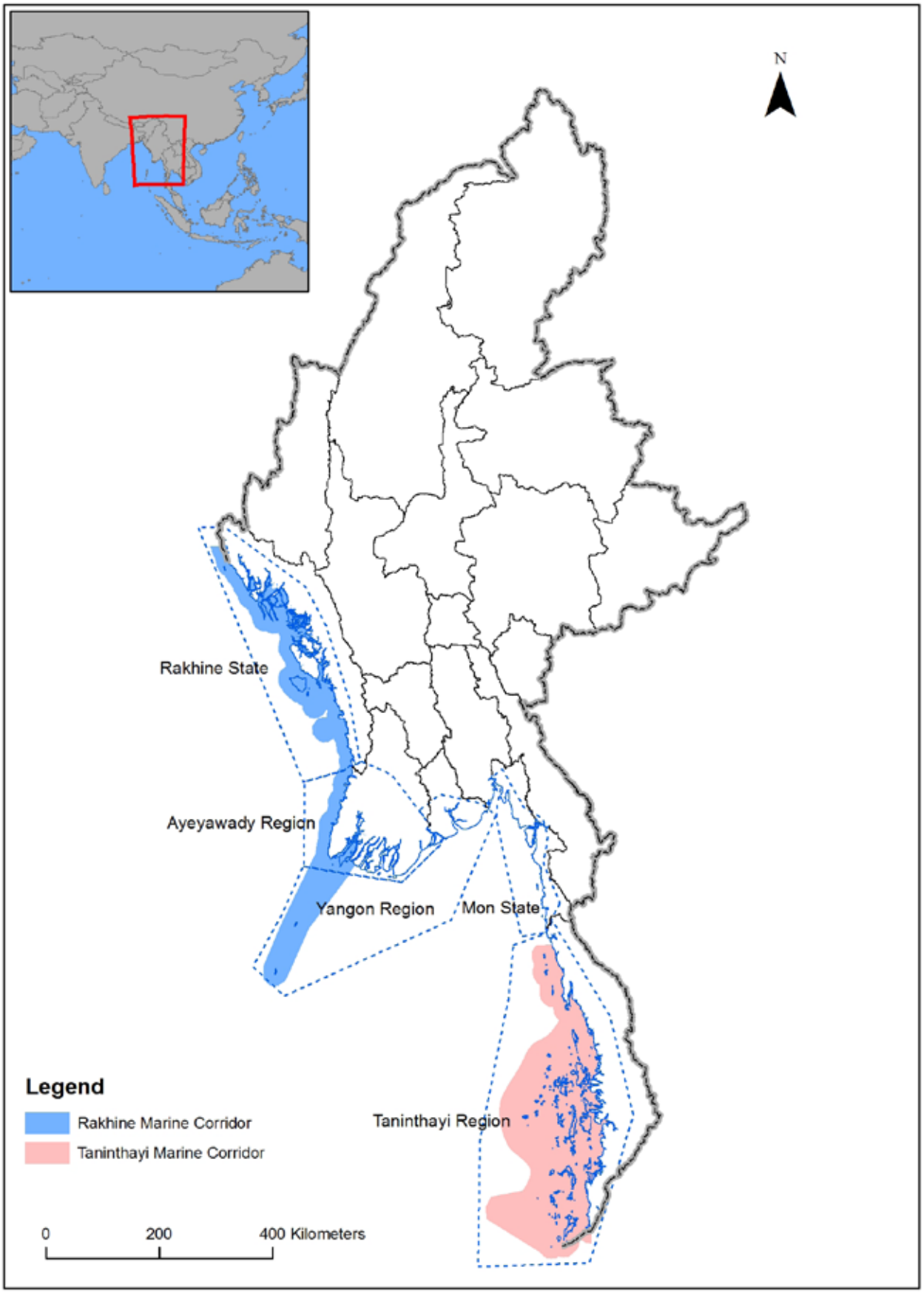


Figure 1. Priority marine Conservation Corridors as identified within the Myanmar Biodiversity Conservation Investment Vision. The Rakhine Marine Corridor in the north includes the coast of Rakhine State, the western coast of Ayeyawady Region and some isolated islands of Yangon Region. The Taninthayi Marine Corridor includes the coasts and islands of Taninthayi Region.

Myanmar's main coastline of approximately 2400 km is, perhaps, the most intact coastline in all of mainland Southeast Asia. The three main coastal areas, from north to south, are the Rakhine Coast (from the mouth of the Naaf River in the very north of the country to Mawtin Point, about 740 km), the Ayeyawady Delta region (from Mawtin Point to the Gulf of Mottama, about 460 km) and the Taninthayi Coast (from the Gulf of Mottama to the mouth of the Pakchan River in the very south, about 1,200 km), plus the coastlines of more than 1700 islands. These waters are thought to harbor some of the world's most important marine biodiversity. Myanmar's nearshore areas and offshore islands provide habitat for populations of globally threatened marine turtles. In the northwest, vast seagrass beds and a large portion of Southeast Asia's remaining mangrove forest provide critical habitat for a range of species, while the southern waters of the Myeik Archipelago in the Taninthayi Region are noted for their rich coral reefs. Despite the presumed intact nature of the marine biodiversity in this area, few assessments have thus far been done to determine the status of marine species and habitats. Existing documentation on the current understanding of critical marine life and ecosystems in the country had yet to be consolidated. Fisheries provide the dominant livelihoods in many of these coastal regions, the extent and sustainability of which is unknown.

A workshop conducted by the Wildlife Conservation Society (WCS) in January 2012 identified the coastal areas of southern Taninthayi Region and a portion of the entire Rakhine Coast as important "Conservation Corridors" that encompass and link Key Biodiversity Areas (KBAs) (Wildlife Conservation Society, 2013) (Figure 1).

To understand the current state of marine resources in the country and to lay a foundation for future marine conservation activities, we complied over 600 papers and reports describing studies that have been primarily conducted by Myanmar scientists on the country's marine biodiversity and habitats. In each of the two priority corridors we performed simple ecological assessments, habitat mapping, participatory mapping and stakeholder interviews. The habitat ground truthing contributed to the development of a GIS database focusing on the coastal habitats of Myanmar. We also conducted a stakeholder workshop to identify priorities for research and conservation activities. From this diverse set of data we have generated recommendations for future marine conservation activities in Myanmar.

© Katherine Holmes/WCS

ACTIVITIES

LITERATURE REVIEW

Throughout the early months of 2013 we visited several libraries and spoke with various researchers and government officials in an attempt to compile as many documents and studies, produced by researchers, that relate to the marine environment in Myanmar.

We targeted libraries at universities that have programmes that study marine systems, namely Yangon University, Dagon University, University of Mawlamyine, Pathein University and Myeik University with a focus on their Marine Science, Zoology, Botany and Chemistry departments. We also visited Diamond Jubilee Hall (also known as Sein Ya Tu Hall) of Yangon University. The building contains the national repository of Doctor of Philosophy theses. References found at universities include departmental reports and theses by candidates for Master of Research, Master of Science and Doctor of Philosophy degrees. Some government reports were collected from the Department of Fisheries (DoF). Various references were also shared with us through private libraries, such as that of U Tint Tun of the Marine Science Association, Myanmar (MSAM), which reflects many decades worth of study and collection. References were also found through intensive online searches. In most cases, these digitally available papers are reports for conferences and commissions and articles from peer-reviewed journals. Online libraries such as university libraries and the Online Burma/Myanmar Library were also consulted.

In many cases we knew of studies that have indeed been conducted but of which we were, unfortunately, unable to find copies. Often findings remain in the grey literature and, over the years, some documents have been misplaced or have been destroyed by mould or book-boring insect larvae.

All references have been catalogued within the newly created Myanmar Marine Reference Database, which is a searchable database. Most entries include an abstract plus keywords, species lists and location data, when available. This database will be shared with researchers in a digital form and available online. As rare copies of past research surface and new documents are written, the database can be updated.

The names and spellings of Myanmar's districts, villages and features, such as rivers and islands, have changed throughout modern history. In this report, we have attempted to use the modern, currently accepted names. When appropriate, we also include the names as they occurred in the original reference in parentheses.

FIELD VISITS

In January and February 2013, small research teams visited Thandwe District of Rakhine State and the northern islands of the Myeik Archipelago in Taninthayi Region (Figures 2 and 3). Teams were composed of Myanmar biologists with a range of specialties in marine science including knowledge of fisheries, corals, sea cucumbers, seagrass and dugongs, as well as experience in conducting socioeconomic interviews. A GIS expert also accompanied the team.

Together the team collected point data on habitats to inform the GIS data layers, a process known as ground truthing. These data were collected using two methods. A clear bottom bucket placed on the surface of the water allowed the team to clearly see the benthic community from the boat. By using the bucket along with a GPS unit and a depth sounder, the team could evaluate quickly the habitat type, provide a broad description and determine both depth and GPS position from the boat. This approach allowed for fast, broad sampling over large areas.

A slower, more meticulous approach involved using a $1m^2$ quadrat made from plastic pipe and weighted to drop to the substrate. We chose areas to target for sampling, such as a large patch of a particular habitat and sampled along a transect line crossing the area, dropping the quadrat at a set number of fin kicks apart. At each sampling point we determined substrate type, dominant benthic cover, degree of coverage, depth and GPS position and took photos to check benthic coverage and make species identifications, where possible. We did not concentrate our efforts on detailed species collections since other researchers in Myanmar have already conducted intensive taxonomic studies of specific marine groups developing species lists. However, we did create species lists for various taxa seen and easily identified during the spot surveys as well as taxa caught by local fisheries.

Also, at both locales, semi-structured and informal surveys were made of various stakeholders.

SPECIES LISTS

Nomenclature, Species

Certain fields of biological study involve describing, naming and classifying species. As more is learned about species through taxonomic and genetic studies, species are often renamed and reclassified. In this report, wherever possible, we have used the currently accepted name for a species, often alongside the original name that was used when recorded by a scientist within Myanmar. We have referred to reputable online resources as our source for the up-to-date consensus on currently accepted names for various taxa: FishBase for all fish names; AlgaeBase for all algae names; the IUCN Red List for the marine species listed there; the Food and Agriculture Organization (FAO) website for other target marine fisheries; and the Catalogue of Life (CoL), the Ocean Biogeographic Information System (OBIS), the World Register of Marine Species (WoRMS) and the Integrated Taxonomic Information System (ITIS) for all other marine taxa.

BOX 1 | IUCN Red List Categories v. 2013-1

IUCN Red List

The International Union for Conservation of Nature (IUCN) maintains a comprehensive list of the conservation status of threatened animal and plant species called the IUCN Red List of Threatened Species. Each species on the list is classified under one of eight categories according to its status, trends and extinction risk. The Red List has become the international standard for species extinction risk and is used by numerous governmental and non-governmental organisations. We report on the IUCN Red List Categories for species in this report based on version 2013-1.

In this report, we leave the designation blank if a species has not yet been assessed for the IUCN Red List.

Convention on the International Trade in Endangered Species of Wild Fauna and Flora (CITES)

The Convention protects roughly 5,000 species of animals and 29,000 species of plants from overexploitation through international trade. The species are listed under three CITES appendices according to how threatened they are by international trade. They include some whole groups (such as primates, cetaceans, marine turtles, parrots, corals and orchids) but, in certain other cases, include only a species, a subspecies or a geographic population. CITES operates through subjecting international trade in selected species to certain controls. All imports, exports, re-exports and introductions of species covered by the Convention need to be authorized through a licensing system. Each Party to the Convention must designate a Management Authority in charge of administering that licensing system and one or more Scientific Authorities to advise them on the effects of trade on the status of the species. Myanmar became a party to CITES in 1997.

In terms of the marine environment, CITES classifications have been made for cetaceans (dolphins and whales), dugongs, birds, marine turtles, the saltwater crocodile, sharks and rays, sawfish, seahorses, the Humphead wrasse, giant clams, certain cephalopods, black coral and hard corals (Convention on the International Trade in Endangered Species, Web page). When possible, we report the CITES category for a species and list the most conservative category listed.

Species Occurrence in Myanmar

For this report, the occurrence of a species in Myanmar is classified as "confirmed" when we

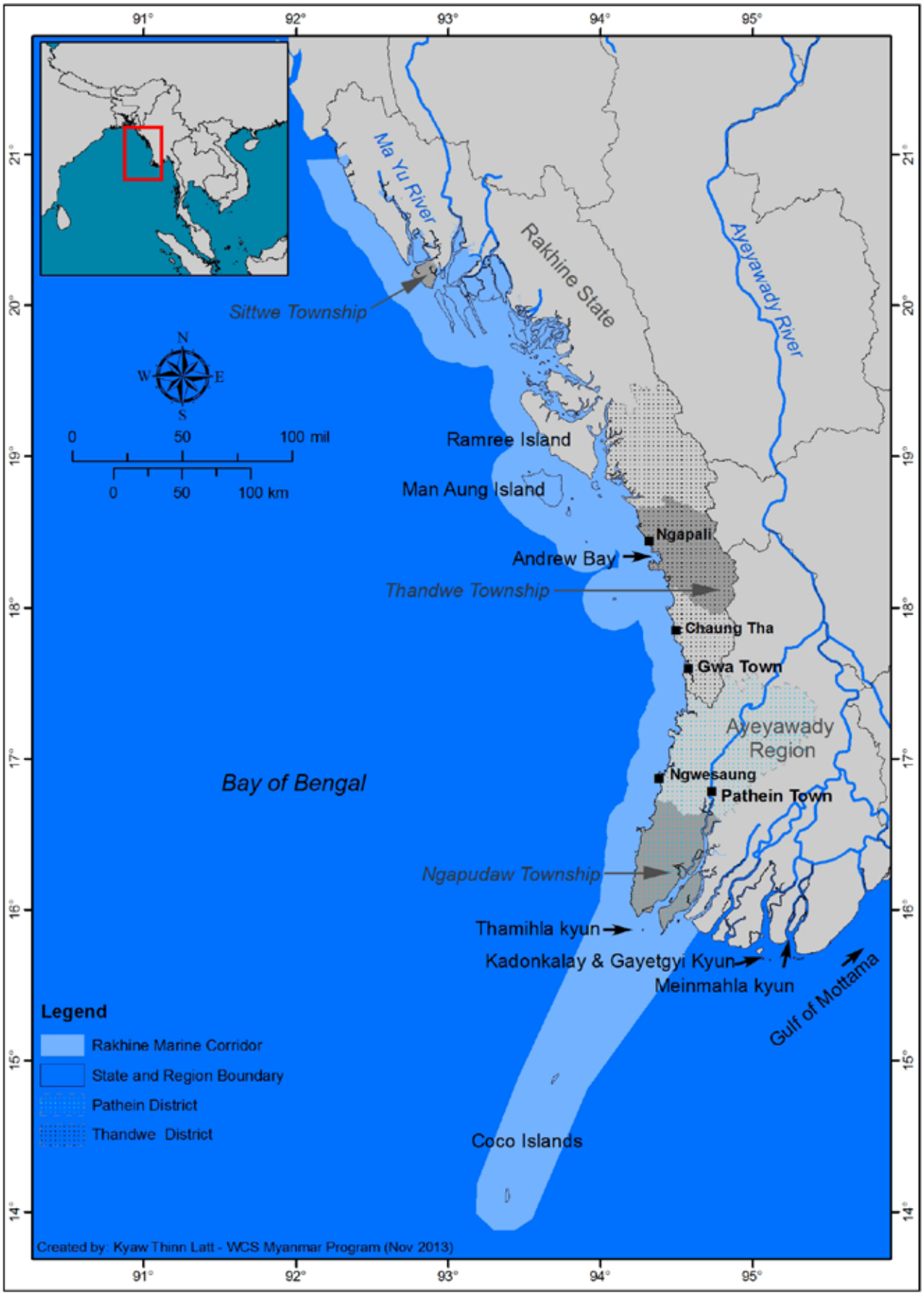


Figure 2. Villages, townships, islands and geographic features of the Rakhine Coast and Ayeyawady Delta that are mentioned in this report.

BOX 2 | CITES Categories

Appendix I Species threatened with extinction. Trade in specimens of these species is permitted only in exceptional circumstances.

Appendix II Species not necessarily threatened with extinction, but in which trade must be controlled in order to avoid utilization incompatible with their survival.

Appendix III Species that are protected in at least one country, which has asked other CITES Parties for assistance in controlling the trade.

can be confident in the identification. For mammals, "confirmed" is used when researchers have been able to make an unambiguous diagnosis through notes from live sightings, photographs, or the examination of skeletal remains. For other taxa where samples can be more easily collected for examination, "confirmed" is used when a researcher has reported a species and its known distribution includes Myanmar.

"Probable" is assigned to a species that is considered likely to be in Myanmar based on its known global distribution pattern. For mammals, there might be unconfirmed local reports, but not a known, confirmed sighting. For other taxa, the distribution includes Myanmar but we do not know of a record for the species, or the distribution shows that the species has been reported in nearby waters and a researcher has reported it in the country. Deeper reviews of collections, theses and publications would be able to confirm some species identifications and elevate their classification from "probable" to "confirmed".

"Possible" is assigned to species where there is some uncertainty whether it occurs in the area. The species might in fact have been reported by a researcher in Myanmar but the current known distribution does not include the country or nearby waters. This discrepancy can be a result of changing knowledge with time and improving identification resources. For example, some older guidebooks do not differentiate the Common bottlenose from the Indo-Pacific bottlenose dolphin but there is now a better understanding of the divergence of these two similar mammals. Recent surveys have only encountered the Indo-Pacific dolphin so earlier sightings of the Common dolphin are, perhaps, questionable.

Species that have been identified in Myanmar but are not reported in the region by authoritative sources such as CoL, OBIS, WoRMS, the FAO, FishBase, AlgaeBase and the IUCN Red List are reported as "unlikely" or are simply not included in the species lists in this report.

These lists are similar in content with those in the Myanmar Biodiversity Investment Vision's lists of Myanmar's IUCN Red Listed species (Wildlife Conservation Society, 2013), although they also include additional species that are not on the IUCN Red List.

STAKEHOLDER WORKSHOP

On 7 June 2013, we held a stakeholder workshop titled "Marine Biodiversity and Conservation for the Sustainable Development of Taninthayi" at the Myeik Hotel in Myeik. The workshop aimed to identify the priorities for research, protection and sustainable development of Myanmar's rich coastal resources. The meeting brought together a wide range of stakeholders including university faculty, retired academics, students, INGOs, LNGOS and government officials from the FD, the DEC, the DoF and the Navy. Fifty-six invitees attended along with many students and academics of Myeik University. See Appendix 20.

Opening remarks were given by U Tin Soe (Minister for Forest and Mines, Taninthayi Region Government), U Mya Than Tun (DoF) and U Than Myint (WCS Myanmar). Presentations by Ms. Katherine Holmes (WCS), Dr. Nang Mya Han (Myeik University), U Mya Than Tun (DoF) and U Tint Tun (MSAM) provided pertinent background information.

BOX 3 | Questions discussed in the breakout sessions of 20-40 persons:

- What are the priorities for future marine research?
- What are the priorities for protection in the marine realm?
- What are the priorities for sustainable development?

TOURISM SURVEY

Starting in late February 2013, we conducted surveys of SCUBA diving tourists and dive guides who were based out of Ranong (Figure 3) and were diving in Myanmar. Through this process, we determined what dive tourists value most on their dive trips. We reasoned that some of this information might be of use to the Myanmar government as the country now looks to develop eco-tourism ventures.

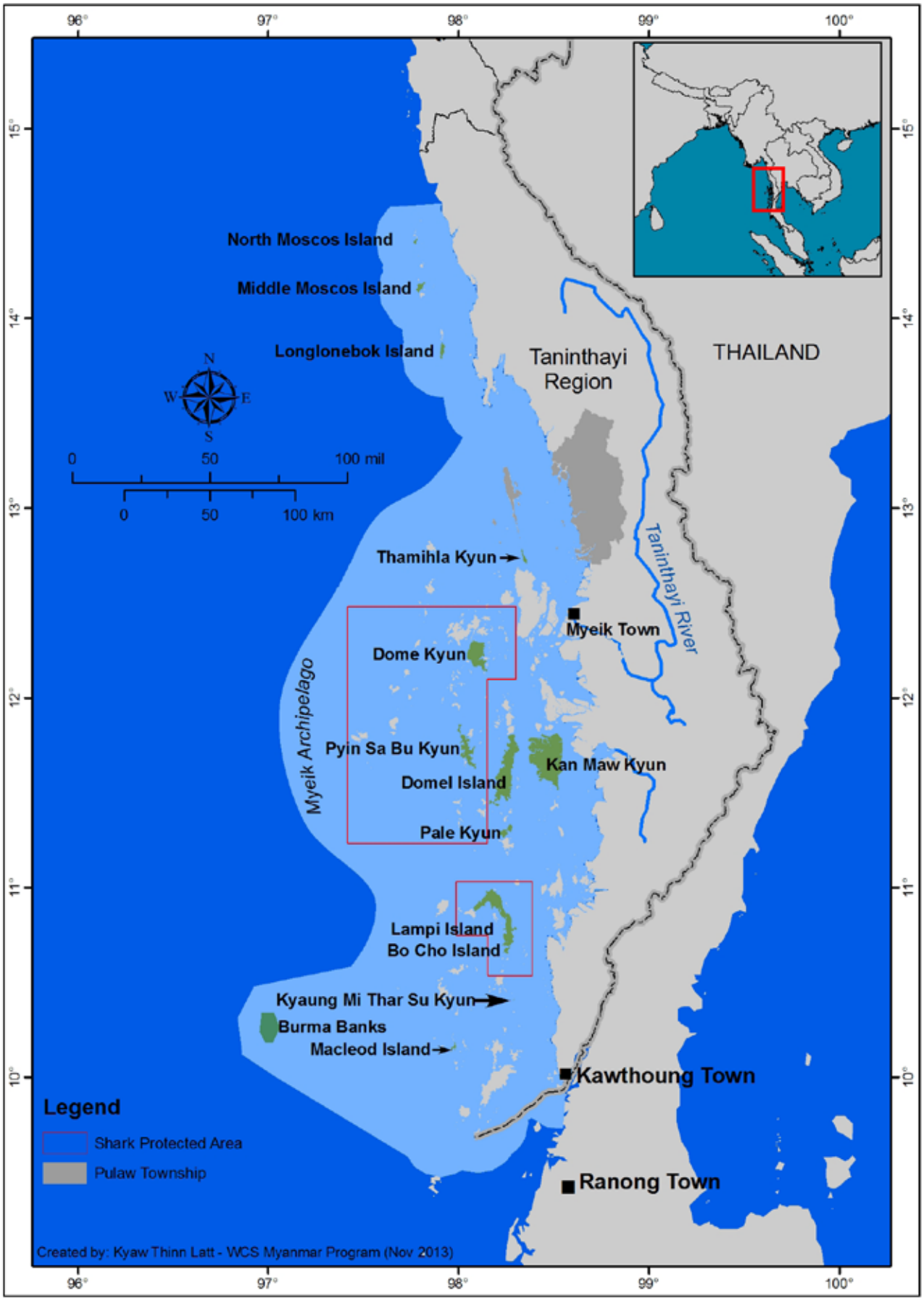


Figure 3. Villages, townships, islands and geographic features of the Taninthayi Marine Corridor and nearby areas that are mentioned in this report.

The information could also help guide the government in marketing and development decisions.

Also, these tourists and dive guides visit areas of Myanmar not easily accessible to local researchers for study. Their observations therefore provide, for example, a useful snapshot on aspects of southern Myeik archipelago's reef health and major stressors. And, through interviewing dive guides who have visited Myanmar for up to seven dive seasons and as far back as 2005, we could learn what changes they have observed over time.

Two standardized questionnaires were developed to target tourists and dive guides who were diving in Myanmar's Myeik Archipelago in early 2013. Surveys contained a variety of question styles to allow for clear analyses of data as well as opportunities for less-directed answers through open-ended questions. Surveys were carried out on diving boats and on land in Ranong, Ko Chang and Ko Phayam, Thailand. One survey was also administered in Myanmar to a dive guide at Macleod Island in the Myeik Archipelago (Figure 3).

The survey was undertaken with guides and tourists from three Ranong-based dive companies: A-One which is Thai-owned, Smiling Seahorse which is owned by a French couple and Aladdin Dive Safari which is owned by a German man and Dutch woman. A fourth Ranong-based company, Andaman International Dive Center, was not included in the survey efforts. It was, however, included in calculations on tourist numbers. Dive operations in Phuket also enter Myanmar waters, though less frequently. We were unable to include these companies in this study. These operations include Santana Diving, Sunrise Divers, MV Sai Mai, as well as private charter boats.

HABITAT MAPPING THROUGH REMOTE SENSING

Initially we accessed global data sources available online through the UNDP's World Conservation Monitoring Centre including the 2010 Global Distribution of Coral Reefs (IMaRS-USF & IRD, 2005a, b; UNEP-WCMC *et al.*, 2010), the 2011 Global Distribution of Mangroves USGS (Giri *et al.*, 2011a), and the 2005 Global Distribution of Seagrasses (Short, 2005). These data are informative on a global scale but are too coarse for local-level analyses. For example, the 2005 Global Distribution of Seagrasses (Short, 2005) includes only large areas of seagrass and misses many of the small and medium patches of seagrass habitat in the country; Lampi Island's largest seagrass meadow of 28 ha was not revealed by their image analyses and does not appear within the dataset.

We visited two areas in the country — Thandwe District in the Rakhine Coast and the northern islands of the Myeik Archipelago of the Taninthayi Coast (Figures 2 and 3) — where we collected data through habitat surveys that could be used in training site development for habitat mapping.

A number of satellite images and vector datasets were used to generate finer-scale habitat maps for this review. The most important was Landsat 8's Operational Land Imager (OLI) imagery. This dataset consists of nine spectral bands with a spatial resolution of 30 meters for bands 1 to 7 and 9, and has a new band 1 (coastal blue) useful for coastal and aerosol studies. Our mapping used thirteen Landsat 8 OLI tiles captured during January and February of 2014 covering the Rakhine and Taninthayi Marine Corridors. This time period matches the season during which our in situ data were collected. In addition to this field data, a second set of observations by Tint Tun & Bendell (2010) were used. These data were collected in 2008 along the coasts of Lampi Island and neighboring islands in the southern portion of the Taninthayi Marine Corridor (Tint Tun & Bendell, 2010). These two datasets were used for training site development.

In preparation for image analysis, the Landsat imagery was radiometrically corrected, a process that converts the raw information captured by the sensor into interpretable values corresponding to elements on the ground. Since both marine corridors have a heterogeneous seascape due to variations in water quality, bathymetry, substrate type, and habitat composition, each was divided into six distinct study areas in a north-south fashion in order to capture the wide variation in habitat composition found in this direction. Land area in the imagery was identified and removed from analysis using a band combination of the red (band 4), near-infrared (NIR) (band 5), and short-waved infrared (SWIR) (band 6).

The training sites for seagrass, coral reefs and other marine habitats were developed separately for each study area based on either available field data or visual exploration using publicly available high resolution imagery from Google Earth and Flash Earth as well as Landsat band combinations. The false color composite with coastal blue (band 1), red (band 4) and NIR (band 5) bands was determined to be the best band combination for training site development to differentiate submerged habitats. Plots of the training sites' spectral signatures were analyzed

and compared to each other and with true signatures from the literature (Guild *et al.*, 2003; Maheswari, 2013).

Among the different classification methods tested, the Classification Tree Analysis (CTA) was determined to be the most accurate. CTA is a powerful classification method due to the transparent and intuitive nature of its method and results. It is also a non-parametric classifier meaning it is ideal for non-normally distributed data such as coral and seagrass habitats. Landsat bands 1 - 5 were used as input to the CTA. The resulting classification was contextually edited based on knowledge of the study area and the habitats' biophysical characteristics. Two decision rules were defined for the contextual editing, (a) redefining improbable classes and (b) filtering to remove isolated instances of habitats.

The resulting classification tree indicated that Landsat 8 OLI's coastal blue band (band 1) was influential in the classification process and provides an additional level of spectral separability compared to earlier Landsat sensors.

Classifying marine habitats in the Taninthayi and Rakhine Marine Corridors presented similar difficulties including signal obstruction by suspended sediment and atmospheric conditions, limited classifiable area, spatial resolution of the data, and spectral separability of the classes. The marine habitat in both corridors was heavily obstructed by suspended sediment and to a lesser extent, clouds and haze. In order to control for the presence of suspended sediment, a separate class was identified in the satellite imagery. In the case of clouds and haze, these areas were identified in the classification process and combined with the water class since they were solely present over deeper areas of water where no seagrass or coral could be identified. Classification was also hindered by natural light attenuation in water, which leads to seagrass and coral being indistinguishable from other habitat beyond depths of 15 m (Mumby & Edwards, 2002; Wabnitz *et al.*, 2008). This difficulty was controlled for by developing classification training sites along the depth gradient. It is important to note that this depth limitation as well as signal obstruction create a limited classifiable area. This may account for under estimation of coral reefs and seagrass beds in our classification. Although highly valuable, the Landsat 8 OLI spectral and spatial resolution present difficulty in that multiple classes may be present in a single 30 m^2 pixel and habitats may be spectrally indistinguishable using the 6 visible and infrared bands. Despite the thorough visual validation included in the study, this can result in confusion among classified habitats.

FINDINGS

SCIENTIFIC RESEARCH

The earliest published treatises on Myanmar's natural history were written by Francis Mason, a missionary and naturalist who moved to Dawei (Tavoy) in 1830 where he oversaw a training college for local preachers. His extensive review of the region's flora and fauna was first published in 1852 (Mason, 1852) and was followed by an improved second edition (Mason, 1860) and a posthumous, expanded third edition (Mason, 1882). John Anderson was a curator and then superintendent of the Indian Museum in Calcutta who, starting in 1864, made collection expeditions to the Myeik (Mergui) Archipelago (Duncan *et al.*, 1889a, b) and upper Burma (Anderson, 1878). He, along with a team of naturalists, conducted comparative studies on the anatomies of many taxa found in the region. The books published by these two naturalists recorded foundational knowledge on the biodiversity of Myanmar and included various marine species.

Modern scientific research of Myanmar's marine resources is richer than many may have realized. Thus far WCS and MSAM have been able to collect over 600 references, including 348 theses, relating to Myanmar's marine resources that cover an expansive range of taxa and topics. We have abstracts for more than 95% of these and full text for more than a third of the references. Much of the information is not easily accessible since the unpublished reports and theses by masters and PhD students are housed in under-resourced university libraries.

Meanwhile, the main sources of government-collected information on marine resources are reports in both English and Myanmar language that are often difficult to locate. Many government officers now share their information outside of their institutions through presentations at meetings and workshops. Increasingly, digital forms of these presentations are being distributed as an effective way to share findings.

The Myanmar Academy of Arts and Science, created in 1999 under the Ministry of Education, is a valued national organisation for nurturing research in the natural and social sciences. It is comprised of experts from across a range of academic fields. The academy conducts seminars every two years and publishes the Journal of the Myanmar Academy of Arts and Science (Myanmar's Ministry of Education website). Prior to this, the country conducted yearly meetings as the Burma Research Congress. Many of the papers presented at these meetings include the foundational studies of Myanmar's marine life. Some universities also produce self-published journals, such as the Myeik University Research Journal, where their researchers can publish their work.

Unfortunately, digital versions of many volumes of these journals are not yet easily accessible online for the international community. Due to strong restrictions over the past few decades, few Myanmar scientists have been able to publish their work in peer-reviewed international journals. These problems have effectively limited meaningful dialogue with the wider, scientific community. This, along with funding and other restrictions, has influenced negatively the nature and scope of the marine research conducted in the country. We were able to find less than 70 articles in international journals that focused on aspects of marine life of Myanmar.

Students have favoured studies that focus on nearshore habitats that are easily accessible such as mangroves (11% of theses) over those habitats that require greater finances and technical skills for study such as coral reefs (3% of theses). They have also tended to focus their studies on lab-based descriptive work, specifically anatomy, histology and morphology (31% of theses) and taxonomy and systematics (18% of theses). They have also concentrated on local-level inventories of species of various taxa (19% of theses). Research that requires expensive laboratory equipment and supplies has not been conducted in the county; for example, not one thesis abstract, including taxonomic studies, incorporated genetics.

Broader-scale concepts such as ecology (9%), conservation (4%) and management (2%) may be touched on within some theses but are only rarely focal points. Review-type publications on various marine and conservation issues appear in peer-reviewed international journals and often are coauthored by foreign researchers in collaboration with local scientists. Over 25% of these journal articles explicitly mention conservation in their abstracts reflecting on the part of the international community a high level of capacity or interest in marine research

relating specifically to conservation. The interest in conservation as a topic of study is growing locally as expressed in the discussions held with university academics and students of marine science during this review and as reflected by scientists' growing attention to the intersection of their respective areas of biological study with conservation issues. Examples of the latter case are Nang Mya Han's (2009b, 2011a, b) reviews of management issues in the Myeik Archipelago. Also, researchers are increasingly able to attend regional conferences that focus on the identification, monitoring and conservation of particular taxa that receive high conservation attention such as sharks, marine turtles, cetaceans, sea grasses, corals and mangroves.

University department heads and lecturers consistently express a need for improved capacity allowing for broader research. They suggest that working with foreign researchers will allow for capacity building and that increased resources will allow them to expand the nature of their research and be more engaged in international scientific dialogue (Rector Dr. Htay Aung, Dr. Khim Maung Swe and Dr. Maung Maung Gyi, *pers. comm.*).

One possible facilitating body for this could be a Marine and Coastal Resources Research Centre. Myanmar's National Biodiversity Strategy and Action Plan (2011) included establishing such a centre among the activities within its "Five-year Action Plan Toward Sustainable Management of Coastal, Marine and Island Ecosystems" and university academics are strong proponents of the idea (Dr. Nang Mya Han, *pers. comm.*). To our knowledge, no formal plans have yet been drawn up for this centre.

MARINE HABITATS

With a coastline of 2400 km plus numerous offshore islands and several large estuarine, delta systems, Myanmar possesses a diversity of coastal habitats including coral reefs, mangroves, mud flats and sandy beaches.

MANGROVES

Extensive mangroves exist on the soft shores where major rivers meet the coast. These rivers include the Ayeyawady, Sittaung and Salween in the Ayeyawady Delta and Gulf of Mottama. Along the Rakhine and Taninthayi Coasts there are smaller but still significant areas of mangroves. Within Southeast Asia and the Pacific, Myanmar had the forth-largest expanse of mangroves after Malaysia, Bangladesh and Papua New Guinea (Ohn, 1992).

Myanmar's mangrove ecosystems are considered part of the Indo-Pacific plant region and share many of the same species with other countries of the region. The main families of mangroves of Myanmar include Avicenniaceae, Combretaceae, Euphorbiaceae, Rhizophoraceae, Sonneratiaceae and Sterculiaceae. The type of mangrove forest is controlled by the frequency, duration and depth of inundation by water as well as by salinity levels (Nay Win Oo, 2004). There are some differences in species distributions and compositions between mangroves of the three major coastal areas (see Appendix 1). *Rhizophora* spp. are more abundant in Taninthayi's mangrove stands and *Avicennia latana* is found only in the Taninthayi Region (Kyaw Tint *et al.*, 2012a).

Mangroves are the most studied marine system in the country. Forty-one theses were identified during the literature review for this report and dozens of studies and reports on the state of Myanmar's mangroves, often with a particular focus on the Ayeyawady Delta region, are widely available online (Food and Agriculture Organization, Web page-d).

Estimates on mangrove cover have varied between sources based on different approaches, time frames, and data used in their calculations (Hexacorallians of the World, Web page; Maung Maung Kyaw, 2012; National Biodiversity Strategy and Action Plan, 2011; Platt *et al.*, 2014). Authors of this report have classified mangrove cover for the two priority marine corridors through remote sensing based on the most recent Landsat 8 data, as summarized in the Rakhine and Taninthayi Marine Corridor sections.

© Tint Tun/MSAM

Mangroves are often removed along coastal areas to improve access to the ocean. In this area of Chaung Tha, fish drying tables are interspersed with a few remaining mangrove trees. Homes along the coast will not be adequately protected by this stand during a storm surge.

Despite the differences in area calculations, it is clear that Myanmar's mangrove forests have been considerably depleted and degraded over the last few decades from charcoal production, agricultural expansion and conversion to fishponds, shrimp ponds and rice paddies (Aye Aye Min, 2011; Hnin Khaing Aye, 2006, 2007; Ohn Mar Myat Oo, 2008; Thanda Win, 2011). Spatial analysis of forest cover change revealed that mangroves are experiencing some of the highest rates of habitat loss in the country with 20% loss of mangrove habitat in the Ayeyawady over ten years between 1990 and 2000 (Leimgruber *et al.*, 2005). A review of encroachment into original mangrove areas as of 2010 by Maung Maung Kyaw (2012) is summarized in Table 1. In the Ayeyawady Region, a striking 92% of the mangrove forests has been affected across all forms of encroachment. Rakhine has lost 42%. Taninthayi's mangroves have fared better, losing only 2.5% (Kyaw Tint *et al.*, 2012a). However this final statistic may be questionable since it varies from data presented through the BOBLME project, which states that Taninthayi mangroves are experiencing a decline of 2.5% per annum rather than total area loss of 2.5% as of 2010 (Angell, 2004).

Where mangroves still form contiguous cover, there may be enough potential for natural regeneration and recovery, but this would require protection from further encroachment and fragmentation. In other areas, replanting methods would need to be used to encourage any recovery as part of a management plan. Mangroves protect riverbanks from erosion and coastal areas from the impacts of major storms. Reforestation has taken place with local mangrove species such as *Avicennia officinalis* and *Sonneratia apetala* along vulnerable riverbanks.

The mangroves of the Ayeyawady were also devastated by Cyclone Nargis in May 2008, which damaged 80% of natural mangrove forests as surveyed by the FD. Natural regeneration has been high, and recommendations were made to reforest the coastal strip and prevent further conversion (Kyaw Tint *et al.*, 2012a). In particular, the FD recommended that a coastal strip of about five miles wide be replanted

Table 1. Encroachment of mangrove forests in Myanmar as of 2010. Source: Kyaw Tint *et al.* (2012a), adapted from a publication by Maung Maung Kyaw (2012).

State/Region	Original mangrove area (ha)	Encroachments in mangrove stands (ha)			Remaining mangrove area (ha)
		Agriculture	Fisheries and Others	Total	
Rakhine State	167,483	22,269	47,695	69,964	97,519
Ayeyawady Region	296,448	107,615	163,985	271,600	24,848
Taninthayi Region	195,103	3,600	1,426	5,026	190,077
Total	**659,034**	**133,484**	**213,106**	**346,590**	**312,444**

and protected from future conversion and that trees be planted within 100 m on either sides of large streams to minimize bank erosion and protect coastal dwellers from strong winds and waves (Kyaw Tint *et al.*, 2012b).

The FD has reacted to this loss of mangrove through implementing mangrove management projects (see Table 2). Around the 1990s, returning control of management rights and responsibilities for village forests to the villages became seen as important by Myanmar's policy makers and, in 1995, the FD initiated their Community Forestry Instruction, which promotes the use of community forestry approaches (Kyaw Tint *et al.*, 2011). In recent years, the FD has been applying their Integrated Management Approach that aims to integrate ecosystem conservation with development needs through raising conservation awareness while rehabilitating degraded habitats (Ei Thandar Bol, 2013).

In the Ayeyawady Delta the "Integrated Mangrove Rehabilitation Project through Community Participation" started in 2007 in cooperation with JICA and is working to establish community forestry, create research plantations and construct nursery centres. By 2011, the project had established 537 ha of research mangrove plantations and 284 ha of community forests as well as constructed four extension centres across four forest reserves, established an agro-forestry project and piloted an oyster farming initiative.

In Rakhine State, the "Sustainable Community-based Mangrove Management in Wunbaik Reserve Forest" project, working in cooperation with the FAO, has conducted socio-economic and fishery resource surveys, workshops and training sessions in order to integrate mangrove ecosystem development with community development (Ei Thandar Bol, 2013). In addition, degraded mangrove forests are being replanted and Community Forests established by the local NGOs BANCA and MERN in Kyaukphyu and Thandwe Districts of the Rakhine Coast (Kyaw Tint *et al.*, 2012a).

The FD will soon be establishing a Mangrove Conservation Division (Forestry Department, *pers. comm.*).

Myanmar's known species of woody mangroves are summarized in Appendix 1.

Table 2. Establishment of mangrove forest plantations in recent years. Source: Ei Thandar Bol (2013).

Year	Rakhine	Ayeyawady	Taninthayi	Total
2009-2010	400	3,000	0	3,400
2010-2011	15	2,450	100	2,565
2011-2012	200	1,500	0	1,700
Total	**615**	**6,950**	**100**	**7,665**

CORAL REEFS

Coral reefs are among the most biodiverse systems in the world and are threatened worldwide. A global analysis conducted by Reefs at Risk determined that, as of 2011, globally, 36% of all reefs are classified as threatened by overexploitation, 30% by coastal development, 22% by inland pollution and erosion and 12% by marine pollution. When these threats are combined, 58% of the world's reefs are at risk (Burke *et al.*, 2011).

The reefs of Myanmar have not been well studied and, as such, the species diversity and health of these systems are poorly known. The main structural animals, corals, and some of the plants and animals that live on reefs during some portion of their lifecycles (fish, marine turtles, crustaceans, molluscs, seaweeds, etc.) are discussed in the sections below.

Coral reefs are well developed around the islands of the Myeik Archipelago and the Burma Banks of the Taninthayi Coast (Figure 3). Fringing reefs surround the islands and species composition can vary dramatically between sites, with certain sites maintaining dominant species that capitalize on species-specific preferences relating to water clarity, depth and exposure. In the Burma Banks, reefs form close to the edge of islands with steeply pitched walls, in between small chains of islands and on submerged pinnacles (K. Holmes, pers. obs.). Along the Rakhine Coast, reefs are less developed and often consist of small patches of corals growing directly on rocky bottom substrate (K. Holmes, pers. obs.). Reefs in the Ayeyawady Region are restricted to the offshore islands of Coco and Preparis (Figure 2) that are suf-

ficiently removed from the high sediment loads from the delta.

Coral reefs support rich communities of reef fish and invertebrates and are highly valued by tourists. As such, reefs are vitally important for sustaining local fisheries and may become increasingly important for Myanmar as tourism develops, in particular within the Myeik Archipelago.

Coral bleaching occurs when environmental stressors cause corals to eject the symbiotic algae living in their tissues. Without these algae, corals turn white and, if the algae aren't reabsorbed from the surrounding water in the near-term, the corals will die. Bleached corals were seen on the reefs of the Myeik Archipelago in 2013 by research divers (U Zau Lunn, *pers. comm.*), SCUBA divers (tourism survey, Appendix 18) and researchers of this study. The degree and distribution of bleaching have not yet been adequately assessed but it appears that this is a widespread and very concerning issue facing the reefs of southern Myanmar. There are a range of triggers that can cause corals to bleach including increased water temperatures, pollution and disease. It is not yet known what is causing reefs in southern Myanmar to bleach.

Myanmar's reefs are also threatened by blast fishing, a simple and destructive fishing method that uses explosives to blow up areas of reef. In addition to killing a few target fish, this method generates tremendous bycatch by killing all other animals in the reef area and destroys reef structures that can take years to recover, if at all. BANCA and FFI staff noted extensive damage from dynamite fishing during reef surveys in northern Myeik Archipelago (U Zau Lunn, *pers. comm.*), as did SCUBA divers in southern Myeik Archipelago (tourism survey, Appendix 18).

Reefs are also damaged by trawling operations that illegally enter into restricted areas too close to shore. Strict guidelines prohibit the use of mechanized fishing gear within five nautical miles of the Rakhine Coast and ten nautical miles of the Ayeyawady Delta and Taninthayi Coasts. Even so, trawlers still sometimes operate too close to shore, dragging reefs and seagrass beds, destroying these habitats (Aung Hlaing Win & Maung Maung Lwin, 2011).

Corals are also harvested, cleaned and dried for sale in the curios trade. Corals are CITES-protected (Appendix II) which means that their international trade is controlled. It is illegal for foreign tourists to carry coral products out of Myanmar and into another CITES-signatory country without special permission. Most tourist shops and tourists are unaware of these laws and the impacts the coral trade has on healthy reefs.

An additional threat to reefs was noticed during the course of this study. The relatively isolated reefs of the Burma Banks are covered with large patches of a species of colonial invertebrate called a corallimorph, which was possibly *Rhodactis howesii*. The presence of these invertebrates indicate that these reefs are likely going through a phase shift in which the dominant organisms (corals) are being replaced by another set of organisms resulting in degradation of the habitat. We cannot be certain of what is causing this shift but various reasons have been proposed for similar shifts, including increased human disturbance, pollution or reductions, through overfishing,

Coral skeletons, along with shells, are cleaned, dried and sold to visitors at tourist destinations such as Chaung Tha Beach.

in coral reef organisms that serve a major ecological function. At Palmyra, an atoll in the Pacific, disturbances caused by a shipwreck resulted in an extensive *R. howesii* invasion (Work *et al.*, 2008). It is possible that these invasions in Myanmar result from either anchor damage from fishing and dive boats or from overfishing of grazing fish. This report is the first to note the prevalence of this organism on these reefs.

There are no protection measures specific to coral reefs in Myanmar. There are three marine conservation areas in the country that encompass coral reefs within their area. The Thamihla Kyun Wildlife Sanctuary is off the Ayeyawady Coast and two others (the Moscos Islands Wildlife Sanctuary and the Lampi Marine National Park) are on the Taninthayi Coast (Figure 6). However these areas have few, if any, reef conservation protection measures in place to make any impact on reef conservation. Another wildlife sanctuary, the Meinmahla Kyun Wildlife Sanctuary in the Ayeyawady, is in a low, flat delta area that is not able to support healthy reef communities.

The various species of fish, algae, and invertebrates (including corals) that inhabit Myanmar's reefs are described in subsequent sections of this report.

Invasive corallimorphs carpet areas of reef in the southern Myeik Archipelago.

SEAGRASS BEDS

Seagrass beds form important roles in tropical coastal ecology. The beds are a key habitat for certain life phases of many species of fish. In particular, they are often the nursery grounds for various juvenile fish that shift to other marine habitats as they develop. The beds are also feeding grounds for invertebrates, marine turtles and dugongs. And their root-like stems stabilize the sea bottom.

Some limited research attention has been given to Myanmar's seagrasses. At least five theses dedicated to nearshore seagrasses have been completed and additional studies focusing on their consumers, such as dugongs and marine turtles, have documented their distribution and importance (Ilangakoon, 2007; Tint Tun, 2011; Tint Tun *et al.*, 2009). Seagrass beds of varying sizes are found along the Rakhine and Taninthayi Coasts. None are found off the Ayeyawady Delta and Mottama regions where the water is too turbid from the enormous sediment discharges from river systems (Soe Htun *et al.*, 2001). Recent studies in the Southeast Asia region are now attempting to understand better the drivers that govern their presence in the different regions where they occur, including estuaries, back-reefs and the poorly-studied fore-reef and deeper water areas (Ooi *et al.*, 2011).

The largest seagrass meadow by Lampi Island was estimated to be 28 ha, and dugongs have left their marks of clearly-defined feeding trails in dense patches of Halophila ovalis (Tint Tun & Bendell, 2010).

Species composition differs slightly between the two regions. The family Hydrocharitaceae includes the most dominant genera (*Halophila*) of both coastal regions and the family Cymodoceaceae (genera *Halodule* and *Syringodium*) is more common on the Rakhine Coast (Soe Htun *et al.*, 2001). It has been reported that *Cymodocea rotundata* occurs only on the Taninthayi Coast (Soe Htun *et al.*, 2009b) but two recent studies have also encountered it in the Magyi

area of the Rakhine Coast (Thaung Htut, 2011; Win Yadana Htay, 2010). Similarly, *Cymodocea serrulata* had only been documented on the Rakhine Coast (Soe Htun *et al.*, 2009b) but studies around Lampi Island of the Taninthayi Coast (Figure 3) have now documented it there as well (Tint Tun & Bendell, 2010). Another species, *Halophila minor*, has thus far only been documented in studies around Lampi Island (Beffasti, 2010) but its currently known global distribution does not extend into Myanmar (IUCN, Web page; Soe Htun *et al.*, 2009b). Further confirmation or additional documentation might firmly establish its validity on the list of Myanmar species. See Appendix 3 for a list of seagrasses encountered in Myanmar.

The seagrass beds of other ASEAN countries have been disturbed or destroyed for a wide range of development-related activities including creation of aquaculture ponds, salt production, ports, urban development, mining, waste disposal and recreation. Various actions have been taken by authorities and NGOs to slow this destruction and mapping is now being used to inform management.

Seagrasses are unable to thrive in areas where sediment and nutrient loads are so high that they impact water clarity, attenuating light below levels needed for seagrass growth and survival (Boer, 2007). In Myanmar, seagrasses are unable to establish in the Ayeyawady Delta due to the high sediment loads entering from the river systems. In the other coastal areas, there are few natural stressors and Soe Htun *et al.* (2009b) have reported that much of the seagrass areas have remained in near-pristine, climax conditions. In contradiction, some other local experts in recent years have reported that seagrass beds have been severely disturbed along Myanmar's coast. Researchers have noted the increased prevalence of "baby trawlers", especially after the loosening of enforcement on their inshore use following Cyclone Nargis in 2008. These operations undoubtedly damage seagrass beds as ocean floor is scraped for shrimp but the degree of these impacts has not yet been evaluated. Mining activities near coasts or estuaries may also be a major threat to sensitive seagrasses through increased sediment loads.

Soe Htun *et al.* (2009b) have suggested that areas of seagrass beds dominated by *Cymodocea serrulata* in the Rakhine and *Cymodocea rotundata* of the Taninthayi coastal regions should be assigned conservation status due to their uniqueness within the country.

MUD FLATS

Intertidal mudflats can be closely associated with mangroves and are often found alongside mangrove stands. In areas that are particularly dynamic, such as the Gulf of Mottama (Figure 2), turbulence and turbidity create areas of shifting sand and mud flats where mangroves are unable to take root.

The mudflats of Myanmar have not yet been well studied or documented. We were able to find only three theses that studied mudflat communities directly, though there are likely more to be found and new efforts to map mudflats are underway by NGOs such as FFI. Tun Tun Zaw (2012) characterized the sediments of the mud flats found at and near the shorelines of the Thanlwin River mouth.

These habitats support a rich species of invertebrates [such as the polychaetes studied by Si Thu Hein (2011)], all of which form the prey base for birds. As such, mudflats are of particular importance for shorebirds that use them as feeding and roosting areas over their migration routes. Among water birds in Myeik Township, mud flats support greater species diversity over freshwater ponds (Soe Soe Than, 2012).

We were unable to conduct field investigations of mud flats for this review.

SAND FLATS

Sand flats are the least studied marine habitat in Myanmar. Local people collect some fauna such as bivalves and sand worms (*Sipunculus nudus*) for subsistence. *S. nudus* worms are collected when water levels are low and are used to prepare a much-loved dish in the Taninthayi Region (U Tint Tun, pers. obs.).

ROCKY SHORELINE

Rocky shores found along both the Rakhine and Taninthayi coasts provide subsistence fisheries for local communities. Octopuses, oysters, seashells and chitons can be gleaned from water pools and rock faces. Studies have been conducted on the rock oysters that are found in this habitat (Htay Aung, 1987, 2011; Htwe Nyunt, 1996; Thi Thi Lay, 1983).

MARINE ORGANISMS

MAMMALS

Myanmar's coastal and offshore waters support marine mammals within the order Cetacea (the whales, dolphins and porpoises), one species in the order Sirenia (sea cows) and a small number of freshwater otters that sometimes occur in coastal marine habitats. Myanmar's marine mammals were first documented scientifically during the British colonial time (Anderson, 1878; Mason, 1852, 1860). Recent research has been conducted on marine mammals in Myanmar by university departments, DoF, WCS and MSAM. Two marine mammals, Irrawaddy dolphins (*Orcaella brevirostris*) and dugongs (*Dugong dugon*), have been protected under Myanmar's Protection of Wildlife and Conservation of Natural Areas Law since 1994 under the category "completely protected".

Cetaceans (Whales, Dolphins and Porpoises)

In scientific classification, the order Cetacea has two extant suborders: the baleen whales (*Mysticeti*) and the toothed whales (*Odontoceti*), which include sperm whales, beaked whales, dolphins and porpoises. However, non-specialists will often logically group them based on size: the larger whales and the smaller dolphins. In Myanmar, whales are called *nga wun, nga wun gyee, wai la or wai la nga*, whereas dolphins are called *linn shuu, lann shuu, labine* or *lann phai* (Tint Tun, 2006).

Whales were documented by Captain Lloyd who named a bay "Whale Bay" in the Myeik (Mergui) Archipelago (east of Kan Maw (Kisseraing) Kyun) because it supported many whales and it was the only area where he saw them in the country (Mason, 1852) (Figure 3). Anderson (1878) made the first scientific description of the Balaenoptera edeni and named it after Sir Ashley Eden, a former British High Commissioner in Myanmar (Burma). The 37 ft (11 m) whale stranded itself 20 miles (32 km) up the Thaybyoo (Thebyu) Creek off the Gulf of Mottama (Martaban) (Figure 2). In this work he also identified another partial specimen from an 84 ft long (25 m) animal collected from an island just south of Ramree (Ramri) Island of Rakhine State (Figure 2) as a Blue whale (*Balaenoptera indicus*, or the currently accepted name *B. musculus*).

Whale skeletons have been preserved and articulated for display at a number of institutions in Myanmar, including at the Marine Science Department of Pathein University, the University of Mawlamyine, the Department of Zoology of Dawei University, the Marine Science Department of Myeik University, the DoF in Yangon and the Yangon Zoological Gardens. However they have yet to be systematically inventoried.

Recent strandings of interest include an individual of the rare Longman's beaked whale (*Indopacetus pacificus*) that has been buried near its stranding site on the western coast of the Gulf of Mottama in Kyauktan Township in 2005 (Figure 2). Photographs confirmed the species identification (Dr. Colin D. MacLeod, *in litt.*). There have been no other reports of sightings of this species in Myanmar and its global distribution is not fully known. A 63 ft long (19 m) Blue whale was found in January 2006, stranded three miles from Ahlup Village in the Paung Township of Mon State. Its skeleton is on display at the University of Mawlamyine and the skeleton of a Blue whale found in 1987 in Andrew Bay (Thabyugyaint) (Figure 2) is on display at the Yangon Zoological Gardens (Smith *et al.*, 1997). A Strap-toothed beaked whale (*Mesoplodon layardii*) was found stranded in the Ayeyawady Delta in February 2011, more than 5000 km outside of its normal range in the southern hemisphere. This occurrence was considered an anomaly and not an extension of the species' distribution (Aung Myo Chit *et al.*, 2012).

Whales can be of important cultural significance in Myanmar. Many fishermen in southern Myanmar believe that sighting a whale while at sea reflects the disapproval of maritime celestial beings for a person's actions, thoughts or statements and people will throw rice and water into the sea to ask for forgiveness. U Shin Gyee is the guardian spirit of marine waters and seagoing vessels are in his charge. A shrine to him in Myeik includes many whale jaw bones that are lashed together and offerings are often made there when boats are launched. Some fishermen also use whale jaw bones as ornaments on their boats (Tint Tun, 2006).

There is a range of traditional beliefs around dolphins. In southern Myanmar, some local people and fishermen believe dolphins will save people in trouble at sea (Tint Tun, 2006). One explained that dolphins are *nat nga* (celestial fish) and the horizontal position of their flukes was created to distinguish them from other fish (Tint Tun, 2006). While some people of Myaybone, in northern Rakhine State, are scared to be sprayed by water from the blowhole of the Indo-Pacific humpback dolphin — whose local name, *a nu* translates to "leprosy" (U Tint Tun, *pers. comm.*) — cast net fishermen in the Ayeyawady River regard dolphins as their parents since the mammals indirectly provide money for their family as do their own parents (U Tint Tun, *pers. comm.*).

Modern surveys of populations of whales and dolphins in coastal waters include the Taninthayi Coast (Nang Mya Han, 2008; Smith & Aung Myo Chit, 2011; Smith & Mya Than Tun, 2008), the Rakhine Coast (Smith & Aung Myo Chit, 2011; Smith *et al.*, 1997) and the Ayeyawady Delta (Smith & Aung Myo Chit, 2011; Smith *et al.*, 2007). Commonly encountered species include the Bryde's whale, Indo-Pacific finless porpoise, and Irrawaddy, Indo-Pacific humpback and bottlenose, Pantropical spotted, and Spinner dolphins (Nang Mya Han, 2008; Smith & Aung Myo Chit, 2011; Tint Tun, 2005). Cetacean catches at fish landing sites and markets were investigated in Myeik and Dawei (Tint Tun, 2006), a study which further confirmed the presence of Spinner, Indo-Pacific humpback and bottlenose dolphins and Indo-Pacific finless porpoises, and which highlighted issues of hunting, the sale and consumption of meat and the incidental catches of these species. Commonly encountered species include the Irrawaddy Indo-Pacific humpback and bottlenose, Pantropical spotted and Spinner dolphins.

It is not yet clear whether there are differences in coastal cetacean populations occurring along Myanmar's three coastal areas. Most studies have confirmed that species of toothed whales have been seen across the three regions. Colour pattern differences have been noted between humpback dolphins observed in the far south and in the north of the country (Smith & Aung Myo Chit, 2011). The sighting of an aggregation of over 100 Indo-Pacific humpback dolphins feeding near Diamond Island in the Ayeyawady Delta may indicate that this open estuarine area is particularly suitable for this species (Smith & Aung Myo Chit, 2011).

One particular dolphin species, the Irrawaddy dolphin (*Orcaella brevirostris*), is found in the tidal areas associated with freshwater inputs of all three regions (Nang Mya Han, 2008; Smith *et al.*, 1997; Smith & Mya Than Tun, 2008). The species is also found in the upper reaches of the Ayeyawady (Irrawaddy) River, from where it obtains its common name. As with most river populations of the Irrawaddy dolphin, the primary threat to coastal populations is incidental killing from gillnet entanglement.

Coastal populations of other species of dolphins are similarly threatened primarily by entanglement in fishing gear. A survey of the Myeik Archipelago of the Taninthayi Coast counted more than 2500 gill netters and longliners, 1300 squid jiggers and 500 stern trawlers along a survey trackline of less than 1000 km. Concentrations were particularly high in

Whale skeletons are displayed in many areas of the country, including this Bryde's whale skeleton in the Myeik University's Marine Science Museum.

shallow nearshore waters and in a bay where sightings of Irrawaddy dolphins and Indo-Pacific finless porpoises were made (Smith & Mya Than Tun, 2008). Fishermen along the Rakhine Coast reported dolphin deaths from entanglement in gill nets. Many fishermen claimed that they would release a dolphin if found alive, but there are few incentives to save the animal because the carcass can be rendered for oil, which can be sold for medicinal purposes (Smith *et al.*, 1997). The fish landing sites study revealed that dolphin are caught unintentionally through entanglement in purse-seines, beach-seines, gill nets and longlines as well as intentionally hunted using harpoons (Tint Tun, 2006). Drifting gill nets are likely the most hazardous fishing gear to small cetaceans.

A no-fishing zone was established by monks of the Namada Pagoda and Monastery along three miles (4.8 km) of the Ma Yu River of the Rakhine Coast (Figure 2) (Smith & Aung Myo Chit, 2011). Although not legally gazetted, this restriction is observed by local fishermen because of their respect for the head monk. During a census of fishing gear, no activity was seen in the zone while plenty of fishing activities were seen outside the zone. This zone is just downstream of a channel confluence and, therefore, provides ideal conditions for Irrawaddy dolphins (Smith & Aung Myo Chit, 2011).

Species of priority conservation interest in the coastal waters of Myanmar include the Irrawaddy dolphin and the Indo-Pacific finless porpoise due to their status in the IUCN Red List as Vulnerable. Other species under going taxonomic revision and potentially also of conservation interest include the *chinensis* and *plumbea* types of Indo-Pacific humpback dolphins *Sousa chinensis* (Mendez *et al.*, In press; Mendez *et al.*, 2013) and the small form of Bryde's whales occurring in the northern Indian Ocean (Kershaw *et al.*, 2013) The nearshore distribution of the small form of Bryde's whale – which places these animals in environments heavily used by humans – also makes the conservation of this species a priority in Myanmar. For a list of cetaceans of Myanmar see Appendix 4.

In recent years, Myanmar scientists have attended local training courses coordinated through WCS and DoF (Smith, 2005). They have also been involved in regional workshops that aim to train biologists on identification and research techniques used broadly to study cetaceans. One recent course, "Survey Techniques for Marine Mammals" (Phuket Marine Biological Centre, October 2012), introduced two lecturers from the University of Mawlamyine to techniques, such as acoustic tracking, that require equipment, budgets and additional technical training that are not available at local institutions (Rector Dr. Htay Aung, *pers. comm.*).

Dugongs

In Myanmar, dugongs (*Dugong dugon*), are known as *ye wet* which translates as "water pig" and *asye thu ma* which translates as "mermaid" (Tint Tun *et al.*, 2009). Some fishermen do not distinguish between dugongs and dolphins (Smith & Aung Myo Chit, 2011), while others believe that they are a transitional phase between dolphins and pigs (U Tint Tun, *pers. comm.*).

In 2005, researchers conducted the first dedicated dugong survey, based on interviews with local communities covering areas of the Rakhine Coast (Tint Tun & Ilangakoon, 2006) and the Myeik Archipelago. This work was important since previous global assessments and conservation action plans did not adequately include Myanmar among its lists of countries with dugongs (Marsh, 2002).

Dugongs have been reported along the Rakhine and Taninthayi Coasts, but not in the Ayeyawady Delta since it does not support the seagrass areas required by the animals for feeding (Figure 4) (Nang Mya Han, 2009a; Tint Tun, 2010).

The IUCN Red List currently categorizes dugongs as Vulnerable (IUCN, Web page) and the Convention on Migratory Species lists the dugong in Appendix II, which means that the conservation of the species would benefit from international cooperative activities organized across the dugong's migratory range.

Myanmar was one of the first signatory states to sign "The Memorandum of Understanding on the Conservation and Management of Dugongs and their Habitats throughout their Range"(United Nations Environment Programme, 2007). As of February 2013, 26 countries have signed this MoU which is designed to facilitate national level and trans-boundary actions that will in turn lead to the conservation of dugong populations and their habitats (United Nations Environment Programme, 2007).

Dugongs are not largely targeted by fishermen in Myanmar, though some Moken people from southern Myanmar explained that if a dugong is seen or stranded, they will kill and eat it (Hines *et al.*, 2007). In Man Aung of the Rakhine Coast (Figure 2), fishermen admitted to hunting dugongs with harpoons in the past, but also claimed that they are no longer targeted (Tint Tun & Ilagankoon, 2008). However some people from the area said that the

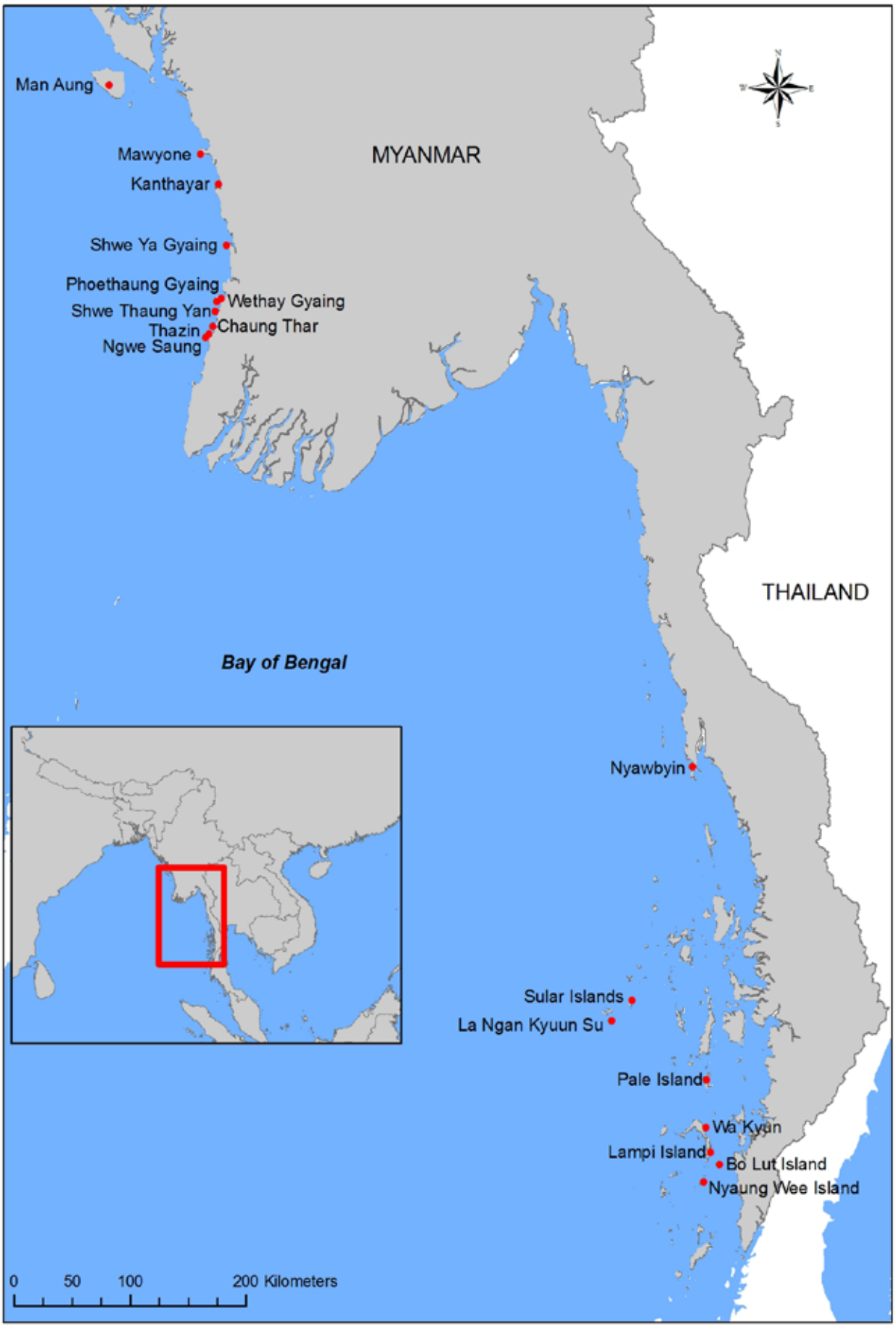


Figure 4. Localities from where dugongs (*Dugong dugon*) have been recorded along Myanmar's coast. Adapted from: Nang Mya Han (2009a) and Tint Tun (2010).

meat from dugongs tastes better than pork (Tint Tun & Ilagankoon, 2008). Interviews in southern Myanmar revealed no medicinal uses derived from dugongs (Hines *et al.*, 2007), while people of Man Aung Island feel that dugong body parts can help cure afflictions including diarrhea and warts, and a local book explains that the dugong tusk has strong medicinal properties (Tint Tun *et al.*, 2009).

The local DoF has conducted active education campaigns in Man Aung Island and fishermen are indeed aware that the animals are both rare and are under protection from the government and that they must release a dugong if it is found alive in their nets (Tint Tun & Bendell, 2010). Unfortunately, accidental mortality through entanglement in fishing nets is reported still to occur in the area (Tint Tun & Bendell, 2010) and is likely the main threat to dugongs in the country.

Otters

Freshwater otters, most likely the Smooth otter *Lutra perspicillata* or the Small-clawed otter *Aonyx cinerea*, have been reported in coastal habitats of Pyin Sa Bu Kyun (Bentinick Island), Poni (Pocock) Island, Kyaung Mi Thar Su Kyun (Cat and Kitten Island), Bo Cho (Pu Nala) Island and Thit Yar Wa Village near the town of Myeik (Figure 3). There are no known studies of otters in Myanmar.

REPTILES

Marine Turtles

Nesting marine turtles are known from several locations along Myanmar's coast and offshore islands (Thorbjarnarson *et al.*, 2000b). In 2001, Myanmar became a signatory state to the "Memorandum of Understanding on Conservation and Management of Marine Turtles and their Habitats of Indian Ocean and South-East Asia" (Indian Ocean and South-East Asian region [IOSEA], 2009). The distribution of the five species of marine turtles across Myanmar's States and Regions is summarized in Table 3. See Appendix 5 for a summary of the marine turtles of Myanmar and the corresponding IUCN Red List Status for each species.

Since 1905, marine turtles have been protected under Myanmar (Burma) laws. On paper, the Fishery Act protected all species of marine turtles for conservation purposes through protecting hatching areas and legislation was strengthened further in 1924 through the FD (Agriculture) Notification No. 1/1924. In February 1993, the Ministry of Livestock and Fisheries issued Notification No. 2/93 relating specifically to sea turtle conservation (Myint Pe, 2003).

Prior to 1986, the DoF leased beaches for egg collection. From 1986 to 1996 the egg collection programme was run through local fishing communities, which were required harvesters to leave one-third of the eggs to hatch, though compliance with these regulations was almost non-existent (Thorbjarnarson *et al.*, 2000b). After 1997, the DoF declared all offshore turtle nesting beaches as fully protected and created a conservation programme in collaboration with SEAFDEC and the IOSEA Technical Support and Capacity-Building Programme.

Programme activities involve nest-monitoring, establishment of hatcheries to incubate transplanted nests, and even the relocation of villages to reduce the impact on nesting turtles (Thorbjarnarson *et al.*, 2000b).

Turtle eggs are still collected illegally for local consumption and are also sent to and sold illegally at urban markets. Marine turtles can drown in shrimp trawls, become entangled in fishing gear and die after eating ocean trash such as plastic bags. Turtles are also caught for their meat. It is unclear the degree to which trawlers use Turtle Excluder Devices (TEDs) and gill nets are cited as a major source of death through drowning (Aung Hlaing Win & Maung Maung Lwin, 2011). In the waters around Lampi Marine National Park, fishermen identified long lines, dynamite fishing and commercial trawling as the primary threats to mature turtles. And egg harvest at Lampi Island's six nesting beaches is high (Platt *et al.*, 2014).

BOX 4 | DoF and SEAFDEC's objectives for marine turtle conservation and management

- Preserve and restore developmental, feeding and nesting habitats
- Make nesting beaches acceptable to turtles by eliminating, through technology, legislation and public information, the impact of artificial lighting
- Clean beaches and control predators
- Minimize pollution of the marine environment
- Increase public awareness and participation in marine turtle conservation through public education

Table 3. The distribution of five marine turtle species within Myanmar. Adapted from: Aung Hlaing Win & Maung Maung Lwin (2011).

Scientific Name	Common Name	State/Region				
		Rakhine	Ayeya.	Yangon	Mon	Tanin.
Caretta caretta	Loggerhead turtle	X				
Chelonia mydas	Green turtle	X	X	X	X	X
Lepidochelys olivacea	Olive ridley turtle	X	X	X	X	X
Dermochelys coriacea	Leatherback turtle	X	X	X		X
Eretmochelys imbricata	Hawksbill turtle	X	X	X		X

In 2004, the DoF in collaboration with SEAFDEC conducted trials and demonstrations of TEDs with shrimp trawlers in Thandwe District of Rakhine State (Food and Agriculture Organization, Web page-a) (Figure 2) but they have not yet been adopted.

Most of the small, recently-formed islands off the mouth of the Bogale River of Bogale Township in Ayeyawady Region are used by marine turtles for nesting. Most nesting is by Olive ridley turtles (70%), followed by Loggerhead turtles (20%) and Green turtles (10%). According to the DoF, the total number of nests in the region is currently about 300 annually, indicating a drastic reduction in regional turtle populations during this century. Kadonkalay Kyun (Figure 2) is the largest island at 2.6 km^2 and continues to lengthen. Approximately 180 turtle nests are found each year along the eastern shore. Gayetgyi Kyun (Figure 2) formed about 30 years ago and supports about 80 turtle nests annually. Nests are also found on nearby, newer, smaller islands (Thorbjarnarson *et al.*, 2000b). Starting in approximately 2001, nesting marine turtles have been tagged and regularly monitored at these Islands (Ko Myint, 2005, 2007, 2009; Maung Maung Lwin, 2007).

Thamihla (Thameehla) Khun near Mawtin Point of Ayeyawady Region was designated a wildlife sanctuary in 1970 (Figure 2). A turtle hatchery was established on the island in 1986 and 1987. A number of studies have been conducted on the hatchery and nesting populations (Kay Thi, 2009; Kay Thi *et al.*, 2011; Ko Myint, 2007, 2009; Limpus, 2012; Maung Maung Lwin, 2009a, b). Unfortunately, despite the management actions of recent decades, there continues to be an alarming long-term decline in marine turtle nesting populations (Limpus, 2012). Based on egg collection data from the late 1890s (Maxwell, 1911b), interviews with a local person on collections in 1932- 1941 (Limpus, 2012), a report on egg production in the late 1990s (Thorbjarnarson *et al.*, 2000b) and two decades of turtle nesting censuses by the DoF, Limpus (2012) summarized the long-term declines as follows:

- Green turtle nesting numbers have declined from thousands of nesting females per year — approximately 5,000 according to Maxwell (1911b) — to a few tens of females at Thamihla Island.
- Olive ridley turtle nesting numbers have declined from thousands of nesting females per year — approximately 3,750 according to Maxwell (1911b) — to a few tens of females at Thamihla Island.
- Hawksbill turtles, which nested in the hundreds at the turn of last century, are now approaching extinction as a nesting species in Myanmar.

Moscos Island Wildlife Sanctuary in the Dawei District of Taninthayi Region supports the main, known Hawksbill nesting area of Myanmar. DoF started studying the Hawksbill populations of Longlonebok Island (South Moscos) around 2005 (Figure 3). They have also been conducting awareness and education activities and prohibiting the use of harmful fishing gear (Soe Thant & Maung Maung Lwin, 2011).

Three species (Leatherback, Green and Hawksbill) are moderately abundant in the waters of Lampi Marine National Park, however nesting is not high. Recent interviews of local fishermen suggest that only around 20 trackways are typically sighted per year across the island's six nesting beaches (Platt *et al.*, 2014). Considering the low number of nests and high degree of egg harvest, it's highly unlikely that recruitment is currently occurring in the park.

The DoF State/Regional and District level offices distribute questionnaires and "Tag Wanted" posters to help with data collection efforts. Their efforts to obtain feedback from fishers has been challenged by a number of issues including the fishermen's reticence to share information on catches because they fear prosecution (Aung Hlaing Win & Maung Maung Lwin, 2011).

Despite strict laws, extensive research activities, outreach efforts and hatchery operations, Myanmar's marine turtles remain in peril. Limpus (2012), posits that if management of marine turtles does not improve, Myanmar's breeding turtle populations will be extirpated within a few decades.

Estuarine Terrapins

The Mangrove terrapin, *Batagur baska,* inhabit mangrove swamps, coastal rives and estuaries from India to Malaysia and Indonesia (IUCN, Web page). The closely-related Southern river terrapin, *B. affinis*, is known to occur in southern Thailand, Cambodia, southern Vietnam, peninsular Malaysia, Indonesia and Cambodia (Iverson, 1992; Praschag *et al.*, 2007). These two river turtles once inhabited coastal estuaries and shared nesting beaches with marine turtles in Myanmar. Populations of both species have declined dramatically throughout their ranges due to harvesting of adults and eggs, clearance of mangroves and destruction of nesting habitat (Das, 1997; Moll & Moll, 2004; Moll *et al.*, 2009). The IUCN Red List lists *B. baska* as Critically Endangered (IUCN, Web page).

Mangrove terrapins were once common in the Ayeyawady Delta (Maxwell, 1911a; Theobald, 1868) but this population was extirpated by egg collecting (Thorbjarnarson *et al.*, 2000a). Field surveys in 2004 revealed small populations of the species in scattered locations in Mon State, Taninthayi Region and Ayeyawady Region (Platt *et al.*, 2008). However, surveys in 2014 by the same researchers added to a growing body of evidence suggesting that extant populations of *B. affinis* and *B. baska* no longer occur in Myanmar (Platt *et al.*, 2014).

Crocodiles

The Estuarine crocodile (*Crocodylus porosus*) was once widespread and abundant in the swamps of Myanmar (Thorbjarnarson *et al.*, 2000a). Their numbers have declined precipitously over the past 50 years as a result of commercial hunting for skins, collecting to stock crocodile farms and loss of habitat through the conversion of wetland habitats for agricultural use. Extant populations persist only in the Meinmahla Wildlife Sanctuary of the lower Ayeyawady Delta (Figure 2). This is one of the few extant populations in mainland Southeast Asia. Surveys in 1999 and 2003 revealed that the remaining population was robust and likely to increase and continued monitoring was recommended (Thorbjarnarson *et al.*, 2006). Even so, the sanctuary has received little attention in recent years and the current status of this important, remaining population is unknown.

Recent surveys in Lampi Marine National Park suggest that *C. porosus* is now extirpated from the island, most likely as a result of chronic egg collection and harvesting of the adults (Platt *et al.*, 2014). However, recovery of *C. porosus* in the park could be possible with effective conservation measures, given the proximity of potential source populations on the Tanintharyi mainland and other islands in the Myeik Archipelago (Platt *et al.*, 2014).

The Myanmar government established the Thaketa Crocodile Farm in 1978 in a suburb on the eastern outskirts of Yangon (Aung Moe, 1993). From 1978 to 1999, over 4000 crocodiles were collected from the wild to stock the farm (Thorbjarnarson *et al.*, 2006) likely from Rakhine State and the lower Ayeyawady Delta (Caughley, 1980; Thorbjarnarson *et al.*, 1999). Originally the farm was intended for commercial skin production, tourism, and conservation and research, however, once hatchlings started to be produced in 1982, it became apparent that commercial skin production was not economical and emphasis shifted to the production of founder stock for farms in other countries (Platt *et al.*, 2013). The farm has minimal conservation value since it does not support the viability of wild populations and was a major drain on wild populations at its outset. Furthermore, three Siamese crocodiles (*C. siamensis*) were once introduced to the farm and it is not known if these individuals hybridized with *C. porosus* stock. All the farms' crocodiles, except wild-caught founders, must be regarded as potential hybrids. As such, none of the farmed crocodiles should be released into the wild without prior genetic screening to eliminate hybrid individuals (Platt *et al.*, 2013).

MARINE FISHES

Fish are an important component of the diet of Myanmar's people and are economically vital. The Myanmar government estimates that the fisheries and aquaculture sector employs over 2.6 million people full and part-time.

Small-scale fisheries are generally very close to shore and use low technology approaches for subsistence and some income generation that support local fishermen and their families. This includes gleaning, cast nets and spearguns.

Myanmar's inshore fishery targets areas that are

within five nautical miles from shore along the Rakhine Coast and ten nautical miles from shore for the Ayeyawady and Taninthayi's Coasts. Boats fishing in these areas can be no more than 30 ft long and use engines of no more than 25 horsepower. Typical fishing gears used by these fishers include drift nets, gill nets and longlines. In 2009-2010, a total of 11,681 fishing vessels (including 7981 mechanized and 3700 non-mechanized) were documented by the DoF (Kyaw Tint *et al.*, 2012b).

The offshore fishery extends from the inshore boundary out to the edge of Myanmar's Exclusive Economic Zone (EEZ), which is 200 nautical miles from shore. These fishers use larger boats and gear including bottom trawls, purse seines, surrounding nets, drift nets and longlines. Offshore fishing is managed through a grid of 140 fishing grounds, each a block of 30 x 30 nautical miles (Figure 5).

The major fish landing sites in the country are at Thandwe of the Rakhine Coast; Pazuntaugh, Nyaungdan and Annawa close to Yangon; and Mawlamyine, Myeik and Kawthoung of the Taninthayi Coast (Figure 5). Seasonal fishers also operate their boats from many smaller landing sites along the coasts.

Marine fish production more than doubled from 926,070 tonnes in 2001 to 2,123,460 tonnes ten years later in 2011 (Food and Agriculture Organization, Web page-c). Fishes are the most studied taxa of marine fauna in Myanmar with the major focus on species compositions in target zones — coastal (Kyaw Kyaw Htay, 1985; Thet Myat Lwin, 2006), offshore (May Soe Thu, 1997; Thet Thet Myaing, 2006) and deep sea (Kyaw Kyaw Htay, 2010) — as well as along the three main coasts — Rakhine (Nu Mya Than, 1983), Ayeyawady (Nyein Phyu The', 2005) and Taninthayi (Tin Tin Win, 1992). Most of the fish species specifically identified by scientists in Myanmar are summarized in Appendix 6. As of 2010, the top ten fisheries exports were Rohu (*Labeo rohita*), Hilsa (*Tenualosa ilisha*), tiger prawns, White pomfret (*Pampus argenteus*), live crabs, live eels, dried prawns, pink fish, Tigertooth croaker (*Otolithes ruber*) and ribbonfish. In 2010, fisheries production over all fishery products was 3.92 million tonnes of which 2.61 million tonnes (53%) were marine. Over 2009-2010, Thailand was the greatest importer of Myanmar's finfishes, importing 108,511 tonnes of marine and freshwater fishes, followed by Kuwait, China and Singapore. Exported fishery products accounted for 10% of the total production in 2009-2010.

DoF and SEAFDEC have investigated pelagic fisheries through joint surveys in 2004 and 2007. These revealed that swordfish (*Xiphias gladius*), Yellowfin tuna (*Thunnus albacares*), Striped marlin (*Kajikia audax*) and Indo-Pacific sailfish (*Istiophorus platypterus*) inhabit Myanmar's offshore waters (Kyaw Tint *et al.*, 2012b). In November 2013, surveys of the Rakhine and Taninthayi Coasts were conducted from the research vessel Dr. Fridtjof Nansen and the findings are expected to help the MLFRD update

abundance data for the country's marine fishery resources.

National levels of fish consumption was calculated to be 46 kg per person per year over 2009-2010 (Department of Fisheries, 2010).

Thus far, the main trade in ornamental fish for the aquarium trade has focused on Myanmar's fresh water fish.

Certain marine fish have been given priority status based on their economic importance and threat level. The BOBLME has given priority to Hilsa shad (*Tenualosa ilisha*), Indian mackerel (*Rastrelliger kanagurta*) and sharks for research and conservation efforts. The Myanmar Biodiversity Conservation Investment Vision also suggests priority be give to these same species as well as the Four-finger threadfin (*Eleutheronema tetradactylum*) (Wildlife Conservation Society, 2013).

Sardines and Anchovies

Sardines and anchovies are an important offshore fishery of the Rakhine Coast. The season is dictated by the rains since it is too difficult and dangerous to fish during the monsoon season and not enough fish can be caught to cover fuel and labour costs. Fish are caught at night using purse seine nets that are 600 taung (900 ft) long by 150 taung (225 ft) deep with a ½" mesh. Usually a large boat of up to 50 ft long with a 25 horsepower engine, and a smaller 30 ft long boat, work together to encircle schools of fish. The catches are dominated by anchovies (50-70%) followed by sardines (30-50%) and the composition of the catches change during the season. A sharp decline was noticed by local fishermen between 2004 and 2005 (Stakeholder interviews).

Hilsa Shad

Hilsa shad are anadromous — they spend most of their lives in the ocean and swim up large rivers to spawn. People fish the adults from the marine environment as well as juveniles during their migration from the rivers to the sea. The species is particularly valued by the people of India, Bangladesh and Myanmar where is a prized food fish. They have additional cultural value for some Hindu peoples in the region. India, Bangladesh and Myanmar have been implementing the Hilsa research and conservation activities of the BOBLME project. It is the second-greatest fishery export from Myanmar at 10,968 tonnes in 2010-2011, down from 17,006 tonnes in 2009-2010. Both the catch and the average fish size are decreasing, indicating that the stock is overfished. Hilsa have been widely investigated in Myanmar including studies of their morphometrics, population dynamics and fishery biology (Cho Cho Mar, 1988; Druzhinin & Phone Hlaing, 1972; Hlaing Hlaing Oo, 2012; Kalayar Win Maung, 2007; Khaing

Sardines and anchovies are an important target fishery of the Rakhine Coast. Often other fish species are also caught at the same time.

Myat Myat Htwe, 2012; Kyu Kyu Than, 1978; Lei Lei Khine, 2007; Maw Maw Than, 1991; Min Thu Aung, 2006; Moe Sapai, 1998; Mya Marlar Chan Tun, 1977; Saw Nanda, 2000; Thet Myat Lwin, 2006; Tin Oo, 1983).

Indian Mackerel

Mackerel are caught by purse seines during the dry season (around October to May) with December reported to be the height. The anatomy, fisheries biology and population dynamics of Indian mackerel have been studied by Myanmar scientists (Cho Cho Mar, 1988; Hnin Zar Htwe, 2012; Honey Shwe, 2012; May Soe Oo, 1994; Min Thu Aung, 2006; Moe Sapai, 1998; Saw Nanda, 2000; Thet Swe, 1987; Thet Thet Myaing, 2006).

Four-finger Threadfin

The Four-finger threadfin (*Eleutheronema tetradactylum*) is not well-studied in Myanmar

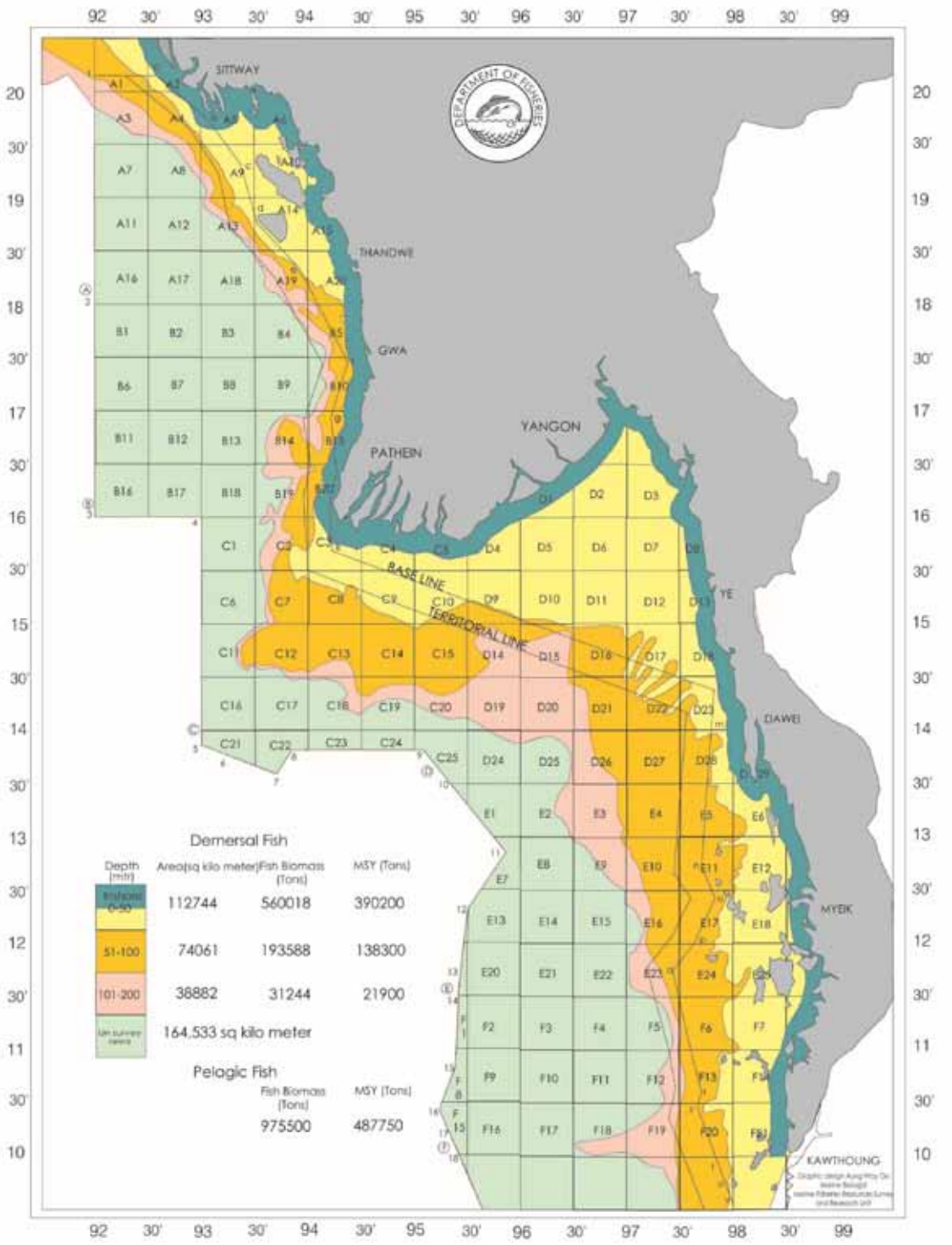


Figure 5. Myanmar's fishing grounds and landing sites. Source: Myanmar DoF.

despite its being a target fish in the country. It was one of the top three species contributing to catch in a study of fishing gear in Taninthayi Region by Min Thu Aung (2006).

Sharks and Rays

Sharks, rays and skates compose the subclass of Elasmobranchii of the class Chondrichthyes, the cartilaginous fishes. Sharks and rays are suffering globally. With the onset of industrial fishing over the past 60 years, their populations have been globally depleted and, of the shark and ray species assessed by scientists for IUCN, 30% are Threatened or Near Threatened with extinction (IUCN, Web page).

Between 26 and 73 million sharks are killed every year to feed the demand for fins to be used in shark fin soup (Clarke *et al.*, 2006), a delicacy in some parts of Asia. And, because most sharks mature late and produce very few young over their lifetime, their populations are slow to recover from overfishing (Stevens *et al.*, 2000). Most sharks are at the top of marine food chains and studies have shown that their presence has important effects on species compositions and health of habitats such as coral reefs, because of the influence they have on prey dynamics (Bascompte *et al.*, 2005; Mumby *et al.*, 2006; Stevenson *et al.*, 2007).

Several studies exist on Myanmar's sharks produced by DoF (Maung Hla & Thein Thein Kyi, 2012) and university staff and students (Khaing Khaing Thein, 2008; Kyi Win, 1978; Maung Maung Winn, 1974; San San Khine, 2010). Fewer studies have targeted rays with only a few theses and reports addressing this taxon (Maung Hla & Thein Thein Kyi, 2012; Maung Maung Winn, 1974; San San Khine, 2010). Many of the known and suspected shark and ray species of Myanmar are summarized in Appendix 7. Skates have not been documented among the studies.

No recent studies have focused on sawfishes in the country but it's possible that Myanmar is one of the few countries to still harbor significant populations of sawfish. Four species are known to have historically occurred in this region: Green sawfish (*Pristis zijsron*), Largetooth sawfish (*P. pristis*), Dwarf sawfish (*P. clavata*) and Narrow sawfish (*Anoxypristis cuspidata*) (Harrison & Dulvy, 2014). Dwarf sawfish are very rare and there are no recent confirmed records of this species from the region.

Some studies report that, in Myanmar, sharks and rays are not directly targeted by fishers but are a secondary catch, essentially "bycatch" of fisheries that use longlines, gillnets, trawls, and purse seines that target finfishes. Vast numbers of fins have been sighted on drying platforms near major fish landing sites and it is not clear if they are targeted or bycatch.

BOX 5 | Reasons that motivated Department of Fisheries to take action:

- Sharks are the most biologically vulnerable creatures in the ocean
- Sharks grow slowly, mature late and bear few young
- Some shark species do not reproduce until they are over 25 years old
- Sharks play the important role of top predator in ocean ecosystems
- Sharks play a role in keeping the ocean balance

Myanmar does not yet have shark and ray identification guides for research but the DoF has relied on regional resources provided through SEAFDEC and FAO (Ahmad & Lim, 2012). However the DoF has produced outreach materials such as posters that emphasize the role of sharks in ocean ecosystems as part of their public awareness programmes.

Myanmar exports shark products, but it does not currently report shark and ray catches to the FAO (Lack & Sant, 2011) although they may be lumped under other broad categories such as "marine fishes". According to available trade data, Myanmar currently exports approximately 270 tonnes per year of shark products (Lack & Sant, 2011).

Diver surveys conducted during this review revealed a consistent perception of dramatically decreasing shark sightings in the southern Myeik Archipelago. Dive guides who have dived in Myanmar since 2005 (three guides) and 2007 (three guides) all reported decreased shark sightings in 2013. Even the five dive guides who only started diving in the area in 2011 each noted a recent drop in shark sightings. That same survey showed that shark sightings currently average one shark every 23.4 diver-hours in the water (see Appendix 18). Similarly, researchers surveying in the Myeik Archipelago in early 2013 saw no sharks in the islands during more that three months of diving (Zau Lunn, *pers. comm.*).

Whale sharks can occasionally be seen in the waters near Ngapali of the Rakhine Coast (Figure 2) and near Thamihla Kyun in Myeik Archipelago (Figure 3) (Tint Tun, *pers. comm.*). Whale sharks are pro-

tected under Notification No. 2/2001, which forbids people from catching, harassing, killing, possessing, selling, buying and exporting Whale sharks. If accidental entanglement in fishing gear occurs, the animal must be released immediately.

In order to address shark conservation needs, the DoF issued Notification No. 2/2004 (5 May, 2004) and created two Shark Protected Areas in Taninthayi of 1706 km^2 and 11,734 km^2.

Shark sanctuaries or parks are not considered a panacea in the conservation of sharks as fishing is often still permitted and there rarely exists the necessary enforcement to render them effective (Davidson, 2012). In 2012, the experts who gathered for the Myanmar Biodiversity Conservation Investment Vision (MBCIV) workshop that evaluated KBAs agreed that both shark protected areas need more information in order to assess their priority value (Wildlife Conservation Society, 2013).

However, as targeted fishing for shark is illegal in the country, it is unclear how restrictions differ inside the two Shark Protected Areas in the Myeik Archipelago. It is also unclear if any patrolling or effective enforcement has been applied within the protected areas.

The DoF has started the process of drafting a National Plan of Action (NPOA) for shark conservation.

It is important to note that these current objectives for the NPOA deal with how shark fisheries are monitored and how captured sharks are utilized but they do not include a key objective of reducing their capture. Also, there are currently no sustainable fisheries for sharks and rays in any developing country (Rachel Graham, *pers. comm.*) so this first objective may not be realistic.

There are several challenges that could affect how successfully the NPOA is implemented. There is insufficient institutional knowledge and experience needed for conducting necessary taxonomic work, financial support is limited, cooperation with fishers and landing site owners may be limited and landed sharks are often missing heads and other body parts that are useful for making identifications. Moreover, key biological information is incomplete, shark trading goes unreported to relevant local authorities leading to a poor understanding of shark marketing channels and data in only one year (2004) has been collected thus far (Maung Hla & Thein Thein Kyi, 2012).

In early 2013, CITES Conference of the Parties 16 supported listing five species of sharks under Appendix II, thus impacting international trade. The Oceanic whitetip Shark, Porbeagle, and three species of hammerheads along with both species of manta rays – all classified as Threatened with extinction on the IUCN Red List – have been added to CITES Appendix II. Of these species, all but the Porbeagle are found in Myanmar's waters. The new listing requires monitoring of trade and an assessment by the exporting country that any trade in a listed species showing it does not threaten its status.

SEAFDEC, which provides a range of support to fishery departments in the region have responded with some valid concerns relating to the training and data needed for countries to be able to establish non detriment findings for listed species and implement effective species identification, export screenings and enforcement (Southeast Asian Fisheries Development Center, 2013). Recognizing that implementation of the listings will take some preparation for CITES countries, Parties decided that the inclusion in Appendix II should be delayed by 18 months, until 14 September 2014.

BOX 6 | NPOA stated objectives

- To ensure the sustainable use of sharks and rays
- To assess threats to shark and ray populations and to provide special attention to the threatened populations
- To minimize unutilized incidental catches, waste and discards from shark and ray captures
- To encourage the full use of dead sharks
- To facilitate the identification and reporting of species-specific biological and trade data and collaboration with biologists in the gathering of these data
- To facilitate improved species-specific catch and landings data and monitoring of sharks and rays catches
- To improve and develop a framework for establishing research, management and educational initiatives for sharks and rays and economic alternatives to their fisheries

Shark fishing is illegal in Myanmar but sharks are still caught and their fins removed and dried to be sold for shark fin soup.

Finfish Aquaculture

Net cage culture is conducted in the Myeik Archipelago and Gwa Township of the Rakhine Coast (Food and Agriculture Organization of the United Nations, 2003; Tin Win, 2002). As of 2010 there were six marine net cage finfish culture farms of the Taninthayi Coast (Department of Fisheries, 2010). Primary species for commercial culture are the Duskytail grouper (*Epinephelus bleekeri*), the Orange-spotted grouper, (*E. coioides*), the Malabar grouper (*E. malabaricus*) and the Greasy grouper (*E. tauvina*) (Food and Agriculture Organization of the United Nations, 2003) but other species of groupers and snappers may be opportunistically reared as well. Seabass (*Lates calcarifer*) is similarly farmed in some areas of the Ayeyawady Delta region.

Grouper is one of the three main aquaculture exports of Myanmar (after shrimp and on par with crab). They are exported either live from Myeik for the live reef fish trade to Hong Kong or chilled. Juveniles are wild-caught by fishermen, often around the full moon using feathered hooks or traps (Food and Agriculture Organization of the United Nations, 2003), while fry are lured and collected using rock mounds, brush piles, brush lures and fish traps (Tin Win, 2002). The fish are grown in floating net cages and ponds.

Production of marine fish through aquaculture is quite small compared with production of shrimp through aquaculture or production of wild caught marine fish. First reported in 2008, FAO reported exports of 135 tonnes of marine fish valued at USD418,000 which has remained level through to 2011 with140 tonnes valued at USD630,000 (Food and Agriculture Organization, Web page).

SEA AND COASTAL BIRDS

Myanmar hosts an incredible diversity of birdlife with over 1100 species known from the country. The variety of habitats along its extensive coastline holds over 80 species that are primarily confined to coastal areas. Many of these species are poorly known because of relatively low survey effort across this huge area. Where surveys have been conducted, a wealth of new information has been obtained. This includes the discovery of large numbers of the Critically Endangered Spoon-billed sandpiper (*Eurynorhynchus pygmeus*). This species was not known from the country until the early 2000s and it is now known that Myanmar supports one of the largest remaining populations of this species in the world.

Seabirds

There are relatively few records of true seabirds, Procellariiformes, from Myanmar. This is rather surprising considering the large amount of sea travel needed to visit the country in historical times. According to Smythies (2001), only a single species of Procellaride has been recorded. The Wilson's storm-

Plain-pouched hornbills (*Aceros subruficollis*), which inhabit the islands of the Myeik Archipelago, are considered Vulnerable by the IUCN Red List.

petrel (*Oceanites oceanicus*) was recorded in large numbers by Davison off the Moscos islands. This species has not been recorded again in the country but there is an ambiguous record of a storm petrel from August 1959 in the Royal Navy Bird Watching Society database (Royal Navy Bird Watching Society, Web page) that could refer to this species or Swinhoe's storm-petrel (*Oceanodroma monorhis*). Recent observations from neighbouring countries, especially India and Malaysia, suggest that many more species could be occurring in Myanmar waters. These include Joaunin's petrel (*Bulweria fallax*) and Streaked (*Calonectris leucomelas*), Wedge-tailed (*Puffinus pacificus*), Flesh-footed (*P. carneipes*) and Short-tailed (*P. tenuirostris*) shearwaters. The location of a submarine canyon off the Rakhine coast could potentially serve as an important feeding area for these poorly known species and should be carefully surveyed to understand the ecology of Procellarids in Myanmar's waters.

A variety of primarily pelagic bird species have been recorded as vagrants to Myanmar. The Red-billed tropicbird (*Phaethon aethereus*) was reported by Davison in Smythies (2001) from Kawthong (Point Victoria) and Mawtin Point (Cape Negrais). Robson (2008) also lists the White-tailed tropicbird (*P. lepturus*) as occurring but the exact location is not mentioned. Smythies reports that a Brown booby (*Sula leucogaster*) was collected by Oates in Tanintharyi (Tenasserim) while a Red-footed booby (*S. sula*) was found exhausted in the Bay of Martaban in 2012 (Ko Lay, *in litt.*) (Figure 2). There is also a recent record of Great frigatebird (*Fregata minor*), also from the Bay of Martaban area (Thet Zaw Naing, *pers. comm.*). All these species are considered to be vagrants to much of mainland Southeast Asia but they may regularly feed in Myanmar's offshore waters. Their occurrence may also be under-recorded because of the relatively small number of observers currently active in the area.

Shorebirds

The group of birds along Myanmar's coasts that have received the most survey effort in recent years are the Charadriiformes. This is primarily linked to the work of BANCA, Birdlife, the Royal Society for the Protection of Birds and others on the Critically Endangered Spoon-billed sandpiper, which are now known to winter in substantial numbers in the Bay of Martaban and along the Rakhine coast (Pain *et al.*, 2001; Zöckler *et al.*, 2010) (Figure 2). Other species of conservation concern found along the Myanmar coast include the Black-tailed godwit (*Limosa limosa*), Asian dowitcher (*Limnodromus semipalmatus*) and Eurasian curlew (*Numenius arquata*), which are all listed as Near Threatened as well as the Endangered Nordmann's greenshank (*Tringa guttifer*) (IUCN, Web page). All of these species are primarily winter visitors to the Myanmar coast, traveling thousands of kilometers from their breeding areas in northern Asia and many of them occur at a much broader range of sites than the Spoon-billed sandpiper. Further survey effort is needed to understand their true status and distribution in the country.

Two other species of shorebird, the Near Threatened Malaysian plover (*Charadrius peronii*) (IUCN, Web page) and the Beach thick-knee (*Esacus neglectus*) are restricted to sandy beach areas in the south of the country. These habitats are likely to be dramatically impacted by the expansion of beach tourism in the area and this will negatively affect the breeding success of both of these species as has already happened elsewhere in the region (Birdlife, Web page).

While not a true shorebird, the Great-billed heron (*Ardea sumatrana*) is another species restricted in Myanmar to undisturbed outer islands along the Taninthayi coast. This species has declined substantially within Southeast Asia and increased development and poorly planned tourism may also negatively impact this species in Myanmar.

Gulls, Terns, Skimmers and Skuas

Several species of gull winter along the Myanmar coast and other species are likely to be found considering this group's propensity to wander widely on their wintering grounds.

Primarily pelagic species that have been recorded in Myanmar as vagrants include the Brown noddy (*Anous stolidus*), Sooty tern (*Onychoprion fuscata*), and Pomarine jaeger (*Stercorarius pomarinus*). Records from elsewhere in the region suggest that these species could be common in offshore waters and a number of additional species could likely occur including the Bridled tern (*O. anaethetus*) and Parasitic (*S. parasiticus*) and Long-tailed (*S. longicaudus*) jaegers. Again the paucity of records for these species in Myanmar is likely due to a lack of observer effort rather than truly low populations.

Numerous species of terns are found along the Myanmar coast and many of these species, such as the Common (*Sterna hirundo*), Gull-billed (*Gelochelidon nilotica*), Whiskered (*Chlidonias hybridus*), White-winged black (*C. leucopterus*), Lesser crested (*Thalasseus bengalensis*) and Caspian (*Hydroprogne caspia*) terns, are only winter visitors to the area. Further work is needed to understand what species are resident and where important breeding locations are found. This could include Little (*Sternula albifrons*), Black-naped (*Sterna sumatrana*), Great crested (*T. bergii*) and potentially Roseate (*S. dougallii*) terns.

Of greatest concern in Myanmar are the populations of three rapidly declining species primarily restricted to breeding on inland rivers. The River tern (*S. aurantia*), Black-bellied tern (*S. acuticauda*) and Indian skimmer (*Rynchops albicollis*) have all experienced catastrophic declines within Myanmar with the Black-bellied tern and Indian skimmer potentially extinct as breeding species within the country. Reports of 28 Indian Skimmers in mangroves on the Rakhine coast in 2008 (Zöckler, *in litt.*) suggest that the area could be an important wintering range for this rapidly declining species. Further work is needed to determine if either species of river nesting tern is also using these coastal habitats.

Offshore Islands

As well as the broad range of bird species that primarily use coastal areas for feeding and nesting, there are a few species that are particularly restricted to offshore islands. These include a suite of nomadic frugivores that are rarely encountered on the mainland, which are likely to be impacted by a similar range of threats to the species already mentioned. The Myeik Archepelago is home to some of the largest known concentrations of Plain-pouched hornbill (*Aceros subruficollis*) in the world. This species makes seasonal movements across the Isthmus of Kra (the narrow neck of southern Myanmar and Thailand that connects the Malay Peninsula to the Asian mainland) from northern Taninthayi to the northern most states of Malaysia (Kedah, Perak and Kelantan) (Wells, 2007). Further study is needed to fully understand the ecological needs of this species and to understand the complex links between roosting and foraging sites on offshore, forested islands and evergreen forests on the mainland as well as seasonal movements.

The offshore islands also host a number of poorly understood species of pigeon including the Pale-capped pigeon (*Columba punicea*), Nicobar pigeon (*Caloenas nicobarica*), Cinnamon-headed green-pigeon (*Treron fulvicollis*), Large green-pigeon (*T. capellei*) and Pied imperial-pigeon (*Ducula bicolor*). Similar to the hornbills, these species travel widely in search of fruit and their exact ecological needs in relation to breeding and feeding sites are still poorly understood (Wells, 2007). The Myeik Archipelago is likely to support substantial numbers of these species but no surveys have been conducted to date. The most well-known species on the offshore islands of Taninthayi are the group broadly known as edible nest swiftlets. These groups of birds are renowned for their edible nests made from the birds' saliva that are sold for considerable sums of money all across Asia to make soup. While local residents historically managed natural nesting areas in caves on offshore islands, they are increasingly attracting the species

to nest in abandoned buildings and purpose-built structures on the mainland to increase production and facilitate easier harvests. The species composition in Taninthayi could involve at least three separate species, all very difficult to distinguish from one another in the field without seeing the characteristics of their nests. The Black-nest (*Aerodramus maxima*), Edible-nest (*A. fuciphaga*) and Germain's (*A. germani*) swiftlets are all reported to occur within Myanmar. True Edible-nest swiftlets are likely to be restricted to offshore islands within the Myeik Archipelago while Germain's swiftlet is by far the most abundant species using man-made structures for nesting and now providing the bulk of the edible nests sold in Myanmar (Poole, 2010).

Mangroves

The extensive mangroves along both the Taninthayi and Rakhine coasts are likely to support a series of mangrove-dependent species. Many of these species are relatively widespread throughout Southeast Asia but several are of high conservation importance. These include the poorly understood and Endangered Masked finfoot (*Heliopais personata*), which are known to breed in mangroves in Bangladesh and historically wintered in mangroves in Thailand. This species' shy and retiring nature makes it very difficult to locate and considerable effort would be needed to understand its distribution in coastal Myanmar. Two other globally Near Threatened species likely to have considerable populations in coastal Myanmar are the Brown-winged kingfisher (*Pelargopsis amauroptera*) and Mangrove pitta (*Pitta megarhyncha*) (IUCN, Web page). These species are likely to be disturbed by increased development and habitat degradation along both coastlines.

The Cocos Islands

The Cocos Islands are found off the southwestern tip of Myanmar (Figure 2) and are home to a suite of endemic species restricted to the Andaman chain of islands further south. The Andaman green-pigeon (*Treron chloropterus)*, Andaman coucal (*Centropus andamanensis*) and the Near Threatened Andaman drongo (*Dicrurus andamanensis*) are likely to still occur, but the globally Vulnerable Nicobar scrubfowl (*Megapodius nicobariensis*) (IUCN, Web page) may already have been extirpated if it ever occurred naturally on the islands (Robson, 2008). These islands have not been surveyed in recent times and it is unclear if healthy populations of any of these species still remain. Additional surveys are needed before the area is further impacted. There are currently a number of proposals to develop the islands for tourism although, at present, transport to the islands is extremely limited making rapid development unlikely in the short term.

The sea and coastal birds of Myanmar are summarized in Appendix 8.

CRUSTACEANS

The subphylum Crustacea, order Decapoda, includes the lobsters, crabs and shrimps.

San Aung & Hla Htay (1986) generated a list of fish, prawns, shrimps and lobsters caught during bottom trawl surveys conducted in 1979 and 1980. Similarly, species caught in a bottom trawl survey in 2007 were reported by Thapanand-Chaidee *et al.* (2008). Crabs and shrimp made up 9% and 4%, respectively, of the invertebrate catches (Thapanand-Chaidee *et al.*, 2010). Species compositions of crustaceans have been reported by Htay Aung (2004) and Maw Maw Myint *et al.* (2004) (Myeik Archipelago); Khin Wai Hlaing (2012) (Mon State); and Aye Aye Khine (2000) (Rakhine Coast).

Decapod crustaceans are caught by artisanal fishermen using shrimp gill nets (also called trammel nets), push nets (for *Acetes* shrimps), tidal set bag nets, stake nets and traps while commercial offshore fisheries use bottom otter trawlers that target primarily shrimp (Htay Aung, 2004). However, push nets are illegal under national fisheries laws since they damage benthic habitats.

Prawns and Shrimps

Shrimps are among the most important fishery resource in Myanmar. Species of both freshwater and marine shrimp are caught and farmed for both local consumption and export.

In the marine realm, a range of fishing methods target different species of shrimp. For example, the commercial bottom trawlers in Myeik catch, primarily, *Penaeus monodon, P. semisulcatus, Metapenaeus ensis, M. affinis* and *Metapenaeopsis stridulans*. A number of different gear types are used by local fishermen, which capture a range of species. Push nets are used along the coast to catch *Acetes* shrimps. The bagnet fishery catches can vary between different regions and tend to catch a subset of a diverse number of species (Htay Aung, 2004). Trammel nets are used close to shore throughout the coastal waters

between the islands of the Myeik Archipelago (Htay Aung, 2004). Larger catches tend to be made from May to August (Stakeholder interviews).

Ngapi, a beloved Myanmar fish paste, is made from *Acetes indicus* shrimps that are partly dried and pounded into a paste with salt.

Marine shrimp fishing effort and catch increased after 1996 when the country's market-oriented economic policy was instituted. In Myeik, the number of fishing vessels and shrimp landings peaked in 2000-2001. After then, the number of vessels leveled off at around 268, but landings declined through to 2004 (Htay Aung, 2004), which could suggest that shrimp stocks were beyond their carrying capacity to sustain existing efforts. However, over the ten year period from 2001 to 2011 official FAO data for all of Myanmar recorded an increase in wild caught marine shrimp tonnage from 27,973 to 94,207 (Food and Agriculture Organization, Web page-c).

Bycatch from commercial shrimp fishing is a major concern since various non-target species are unintentionally captured and killed as bycatch. Numerous species of finfish are caught in trawlers (Maw Maw Than, 1991) and marine mammals are susceptible to entanglement in trammel nets (Reeves *et al.*, 2013) such as those used in the Myeik Archipelago (Htay Aung, 2004).

Important commercial shrimp species vary in their habitat requirements. The whole range of nearshore habitats, such as estuaries, seagrass beds, mangroves and coral reefs, are used by at least one of the commercially important species of shrimp at some point in its lifecycle. Researchers have documented the species composition of the shrimps and prawns of various regions along the coast of Myanmar. This includes the Pathein District on the Rakhine Coast (Aye Aye Mon, 2006; Mar Mar Cho, 2006); the Ngawun River mouth in Pathein District (Gayder Kittim Ku, 2009; Khin Nwe Mu, 1980); the Ayeyawady region (Nant Nay Chit Latt, 2009); Mon State in the northern part of the Taninthayi Coast (Htay Aung, 1982; Khin Wai Hlaing, 2012; Than Than Soe, 2012); the Taninthayi River estuary near Myeik (Htay Aung, 2004; Kathi Khine Soe, 2011); and in the Myeik Archipelago of Taninthayi Coast (Maw Maw Myint *et al.*, 2004) (Figures 2 and 3). Myanmar scientists have also researched the biology of important shrimp species intensively (Htoo Thant, 1987; Khin Htwe Yi, 2000; Khin Khin Htay, 1998; Khin Myint Zin, 1984; Myo Nandar Myint, 2012; Nwe Nwe Ni, 1998; San San Yi, 1997; Swe Swe Myint, 2007; Than Htaike, 1999).

To conserve wild shrimp populations, the DoF issued Notification No. 3/95 (23 March, 1995), which states that the capture, transport, storage, sale and retaining of gravid (with eggs) female shrimps are all prohibited. Fishermen are required to release living female gravid shrimps that have become entangled in fishing gear.

Because of the high demand for shrimp, people throughout Asia have turned to shrimp farming for economic development. Virtually all marine-farmed shrimp are in the genus *Penaeus*. Shrimp farming started in Myanmar in the mid-1970s. People in northern Rakhine State would trap and hold juvenile shrimp in large intertidal areas that supported abundant juveniles (Food and Agriculture Organization of the United Nations, 2003). Since then, there has been substantial encouragement by the government to expand farming operations through training and loan programmes, and organisations like the FAO have contributed to hatchery development, UN agencies have initiated small-scale farms and private aquaculture farms have been established. Shrimp production from aquaculture has increased nearly

Dried prawns and shrimps, shown here along with other dried fish, are important to the traditional diet of Myanmar people as well as a major component of the country's trade exports.

ten-fold from 5,473 tonnes in 2001 to 51,207 tonnes ten years later (Food and Agriculture Organization, Web page-c).

The largest area of shrimp farming is in Rakhine State, followed by Ayeyawady Region and Yangon Region, respectively (Food and Agriculture Organization of the United Nations, 2003). In Myanmar, various researchers have studied aspects of intensive and integrated farming systems (Food and Agriculture Organization of the United Nations, 2003; Okamoto, 2008; Thiri Tun, 2010). Recently, Joffre & Moe Aung (2012) conducted a detailed value chains analysis of prawn farming in Rakhine State that outlined the range of drivers (including high mortality, high costs and impacts from cyclones) that led to a low yield in 2011-2012 and the abandonment of ponds.

In many shrimp farms, mangroves have been converted to aquaculture ponds and there is concern that without proper protection and planning, shrimp farming is leading to dramatic deforestation of mangroves (Aye Aye Min, 2011; Hnin Khaing Aye, 2006, 2007; Ohn Mar Myat Oo, 2008; Thanda Win, 2011) and impacting native animal populations (Khaing Khaing Kyi, 2010). The practice also creates acid sulphate soils (Food and Agriculture Organization of the United Nations, 2003) which can have a range of destructive effects on fish and plant life and is toxic to mangrove trees, making restoration of former shrimp ponds extremely difficult. The productivity of existing shrimp farms that were developed in mangrove areas is low and, in some cases, may be less than the fishery productivity values from the original mangrove stand (Food and Agriculture Organization of the United Nations, 2003). Poor farming practices have also introduced diseases, such at the White spot syndrome virus, into farmed populations and the effects on wild populations is unclear (Food and Agriculture Organization of the United Nations, 2003).

One possibility for rehabilitation of abandoned shrimp ponds is applying aquasilviculture techniques. "Aquasilviculture" is a multiple use approach that promotes the co-existence of fishery species and mangrove tree species in a semi-enclosed system while still allowing for the ecosystem services provided by mangroves (Baconguis, 1991). Typically, ponds are flooded and mangroves are replanted and the remaining 20 - 30% of the area is used to create deeper ponds along the dikes for brackish water aquaculture. Aquasilviculture is practiced in some parts of the Philippines and training was recently provided for some constituents of SEAFDEC.

See Appendix 9 for a summary of marine prawn and shrimp species encountered and thought to exist in Myanmar along with their corresponding current IUCN Red List statuses.

Lobsters

Spiny lobsters of the genera *Panulirus* and *Thenus* live in reefs and rocky areas that provide crevices where they hide during the day. They are caught mainly by traps and bottom set gill nets as well as by free-diving.

A commercial spiny lobster fishery started in 1995 with the export of live lobsters to China and the lucrative fishery has grown dramatically. Increasing fishing efforts have resulted in declines in catch and, increasingly, juveniles are landed (Stakeholder interviews).

The species composition of lobsters has been documented for various regions along the coast of Myanmar: Sittwe of northern Rakhine (Aye Aye Khine, 2000); Chaung Tha of the southern end of the Rakhine Coast (Aye Nyein Thu, 2010); Myeik (Maw Maw Myint *et al.*, 2004); Mon State of the northern part of the Taninthayi Coast (Hnin Ei Soe, 2011); trawls offshore of the Taninthayi Coast (San Aung & Hla Htay, 1986); and Myeik Archipelago (Htay

© Thaung Htut/MSAM

Spiny lobsters are bought by trading companies and held in pens, like this one in Don Nyaung Hmaing Village in the Myeik Archipelago, and then are exported live to overseas markets.

© Katherine Holmes/WCS

Many people buy fresh fish from the smaller landing sites along Ngapali beach during the sardine and anchovy season.

Aung, 2004) (Figures 2 and 3). See Appendix 10 for a list of Myanmar's lobster species.

Panulirus ornatus, found along both the Rakhine and Taninthayi Coasts, is the most valued species by the Chinese market since it is larger and more robust than the other species of rock lobster (Hart, 2009). Other colourful species (*P. homarus* and *P. longipes*) are also valuable, while the less colourful species, *P. versicolor* and *P. polyphagus*, are of the lowest value since they don't look as beautiful on a banquet table (Hart, 2009).

A number of other species of lobsters are likely to be present in Myanmar (IUCN, Web page) but they have not been thoroughly documented or studied unlike the economically important spiny lobsters.

The DoF has designated the coastal area near Ansansan village in Thanbyuzayat Township in Mon State as a lobster refuge (Figure 3) (U Tint Tun, *pers. comm.*).

Crabs

The mud crabs, *Scylla serrata* and *S. olivacea*, are found in mangrove swamps and can be hooked from their burrows and caught with baited traps. Intensive studies of mud crab biology and fisheries have been conducted by many researchers (Hla Hla Win, 2009; Kyi Kyi Maw, 2007; Mie Mie Sein, 2006b; Saw Htoo Baw, 1978; Thinzar Lwin Lwin, 2011).

Mud crabs are cultured in mangroves and mud flats of the Rakhine Coast, Ayeyawady Delta region and Taninthayi Coast. Crabs are caught in the wild and are kept in ponds or in cages kept in river systems and are fattened for six to seven months with chopped fish, shrimps and agricultural byproducts. The practice is less destructive than shrimp farms since habitats are not destroyed (Tin Win, 2002).

Soft-shelled crab is cultured at the Doung Koo Maw farm off of Myeik. Mud crabs (*S. serrata*) are caught using traps in mangrove areas are during the full moon period. They are kept in containers held on rafts in brackish water and fed and monitored until they moult, at which time they are transferred to fresh water to prevent their shells from hardening. They are mainly exported to Japan and Malaysia (Food and Agriculture Organization of the United Nations, 2003).

Another mangrove crab, *Sesarma bidens* (currently named Perisesarma bidens), is salted and exported to Thailand.

Crab is one of the top ten export fisheries products of Myanmar. Annual production of crabs only started being reported in 2008 when it was estimated at 4584 tonnes valued at USD22,920,000. It had decreased to 1,500 tonnes valued at USD8,925,000 by 2011 (Food and Agriculture Organization, Web page-c). In 2010-2011, 19,500 juvenile mud crabs were released as part of a DoF stocking programme (Kyaw Tint *et al.*, 2012b).

In Myeik, people use bagnets to catch crabs of the species *Portunus pelagicus, P. sanguinolentus* and *Charybdis feriata*. Frog crabs, *Ranina ranina*, are caught off sandy bottoms using gill nets fixed to a frame. A fishing ground for these crabs was discovered in Myeik in 2000 and it has since become an

The Pharaoh cuttlefish is commonly seen on the deep reefs off islands of the Myeik Archipelago. A male will mate with a female and carefully guard her from other males while she deposits packets of fertilized eggs into crevasses in the reef.

established fishery (Htay Aung, 2004).

Studies have also been made of non-fishery but ecologically important crabs such as hermit crabs (Mg Mg Gyi, 1993) and the horseshoe crab (Thi Thi Mar, 2009).

The species composition of crabs has been documented for various regions along the coast of Myanmar: Mangroves in Gwa of the Rakhine Coast (Thanda Win, 2011); the Mangroves in the Ayeyawady Delta (Thet Su Mar, 2010); Myeik (Maw Maw Myint *et al.*, 2004); and trawls offshore of the Taninthayi Coast (San Aung & Hla Htay, 1986) and Myeik Archipelago (Htay Aung, 2004) (Figures 2 and 3). See Appendix 11 for a list of Myanmar's crab species.

MOLLUSCS

The molluscs are the largest marine phylum and are highly diverse, demonstrating a wide variety of body forms. In Myanmar, molluscs are important components of both commercial and artisanal fisheries. Some studies have, unsurprisingly, focused on the commercial squid fishery or pearl industry. However students and academics of Myanmar's universities have also conducted studies of some of the less commercial groups (such as the marine snails) so there is some foundational knowledge on the composition of marine molluscs in the country. See Appendices 9 to 11, which summarize many of the known mollusc species identified in Myanmar's waters.

The cephalopods are characterized by bilateral body symmetry, a prominent head and a set of tentacles and include the squids, octopuses, cuttlefish and nautiluses. Jar San (2011) generated a species list of cephalopods for Mon State that is likely representative for the Taninthayi Coast. And some comparative anatomy has been conducted across the groups (Khin Myat Myat Tun, 2000).

All cephalopods believed to be in Myanmar's waters are summarized in Appendix 12.

Squids

The squid fishery is extremely important in Myanmar, both for local people as well as on a commercial scale. Artisanal squid fishing is common among the Moken people who fish from their small dugout canoes either alone or in groups. They tend to fish when the moon is near full to be able to see by its light. They also fish for squids during the day (Tint Tun, *pers. comm.*). In contrast, large commercial boats use light to lure squids. They equip their boats with lines of light bulbs and fish at night during periods when the moon is barely visible. In this way, their lights shine bright in the dark night and the squids will concentrate around their boats.

Squids are the most dominant invertebrate species in Myanmar's offshore waters. In a study of marine fishery resources from bottom trawls, squids were the second-most common catch by weight after a non-target species of lizardfish and made up nearly 50% of the invertebrate catch by weight (Thapanand-Chaidee *et al.*, 2010). However, studies such as this

are not enough to make accurate stock assessment of this important resource.

In a review of squid landings, Thin Thin Maw (2009), identified *Euprymna berryi* in Myanmar, which is outside of this species' FAO-reported distribution (Food and Agriculture Organization, Web page-b).

Octopuses

Octopuses are collected by local people for food or, when possible, sold to local restaurants and hotels. Myanmar researchers have studied aspects of octopus anatomy and morphology (Jar San, 2011; Khin Myat Myat Tun, 2000; Kyi Bin, 1979). In addition to those that have been confirmed, at least two additional species probably also occur in the country (Food and Agriculture Organization, Web page-b) (see Appendix 12).

Cuttlefish

Cuttlefish have been studied by only a few researchers in Myanmar. This group is unique among the cephalopods for their hard, brittle internal structure known as the cuttlebone. They are not a targeted fishery and it's not clear the degree to which they are consumed in the country.

They have been included in inventories of cephalopods (Jar San, 2011; Thin Thin Maw, 2009) and have been subjects of anatomical studies (Khin Myat Myat Tun, 2000; Su Su Khin, 1992; Wai Wai Kan Oo, 1982). Wai Wai Kan Oo (1982) studied the anatomy of a cuttlefish species, *Sepia esculenta*, whose distribution as reported by the FAO does not yet include Myanmar.

In a study of marine fishery resources from bottom trawls, cuttlefish made up over 10% of the invertebrate catch by weight (Thapanand-Chaidee *et al.*, 2010).

Nautilus

Shells of the chambered nautilus, *Nautilus* spp. and *Allonautilus* spp., are well-known collectables and a variety of products are made from their shells. Specimens of *Nautilus pompilius* have been documented in Thailand (Global Biodiversity Information Facility, Web page) near the border with southern Myanmar. These reports have led researchers, such as De Angelis (2012) to suggest that the species might possibly be native to Myanmar as well and their presence might be confirmed in the future.

Shellfish

Myanmar supports highly diverse communities of marine gastropods and bivalves, which include clams, oysters and other molluscs with pairs of hinged shells. Because marine shells have attracted wide global and historical interest of collectors,

Commercial squid boats fish at night using lights to attract squids alongside their boats.

much is known about their taxonomy and various books review the distributions of many species in the world and regionally [for example, see Abbott (1991) or Abbott & Dance (2000)].

Within Myanmar, species lists have been generated for much of the coastline of the country by Soe Thu (1980) and Mar Lar Myo Sein (1982). Since then, other studies have focused on documenting the nearshore species compositions of particular areas: Chaung Tha of the Rakhine Coast (Nan Nwe Nwe Aye, 1998; Sandar Win, 2009, 2011; Sandar Win & Khin Maung Swe, 2011; Soe Than, 2006), the coastal area of Mon State (Naung Naung Oo, 2012), Thandar Island of the Myeik Archipelago (Soe Soe Aye, 2009), the mudflats around the town of Myeik (Phyu Phyu Than, 2012) and offshore communities (Phyu Phyu Khin Win, 1990).

Thesis students have also investigated the taxonomy of the family *Neritidae* (Aye Thida Thein, 1982) and the anatomies of the commercial trochus shell (*Tectus niloticus*) (Hla Hla Aye, 1996) which is an important source of mother of pearl and the spider conch (*Lambis lambis*) (Mya Mya Htwe, 1995) whose unique shell can be sold as curios.

Local people collect a variety of shellfish for food. They are gleaned from pools, rocks and shallow reefs and collected opportunistically from reefs by free divers as they also hunt for lobsters and other target species. A large number are sold to tourists, either as simple, cleaned shells or modified into crafts and souvenirs. This "curios" market is well-developed in Myanmar with complex chains of suppliers, buyers, artists and sellers (Stakeholder interviews) that have not yet been well-documented in reports and publications. The impact of harvesting shells has not been studied in Myanmar and is not well-understood for most species in the world.

Giant clams (of the genus *Tridacna*) are collected, particularly in the Myeik Archipelago, on the same fishing trips when local fishers are targeting a range of species including sea cucumbers and other clams (Nang Mya Han, 2012).

Shells are also ground up and used as an additive in chicken feed to strengthen their egg shells.

Many of the bivalves and gastropods that have been documented in Myanmar's waters are summarized in Appendices 13 and 14. Undoubtedly there are many more species than included in these lists.

Nudibranchs

Nudibranchs are a particular group of animals of the class *Gastropoda* that, unlike marine snails, are soft-bodied with no shell in the adult stage. Nudibranchs are admired for their striking colours and forms. They are not edible and they have no direct economic worth but SCUBA diving tourists value seeing them. There have not been any studies or documentation of this group of animals in Myanmar. During this study, five species were encountered and there are likely many more species in Myanmar's waters (see Appendix 14).

Bivalve and gastropod species of Myanmar are summarized in Appendices 10 and 11.

Nudibranchs, such as this *Chromodoris geminus*, are common on the reefs of Myanmar.

Pearl Oysters

Pearls can be cultured in marine oysters of the genera *Pinctada* and *Pteria* and fresh water mussels of the genus *Hyriopsis*. In 1954, a private Japanese-Myanmar joint pearl culture venture was started on Domel Kyun in the Myeik Archipelago (Figure 3) to produce South Sea pearls from the Gold-lipped pearl oyster, *Pinctada maxima*, which is common in southern Myanmar. After two years, the farm was relocated to nearby Pearl Island (Pale Kyun) (Figure 3). The farm was nationalized in 1963 and after 1988, when Myanmar became a market-oriented economy, it eventually became the Myanmar Pearl Enterprise (MPE) under the Ministry of Mines and opportunities arose for more producers (Tint Tun, 1998). Currently there are both local and foreign joint pearl ventures in Myanmar (Kay Thwe Htwe, 2006).

Before nationalization, pearl seeding — inserting a small "seed" inside the mantle onto which the oyster will deposit layers of nacre, creating a pearl — and harvest were conducted only by Japanese experts and the techniques were kept secret. Once the Japanese left, biology teachers from Rangoon (Yangon) University (U Hia Aung, U Myint Tun, U Htia Aung and U Khin Nyunt) developed seeding techniques. The peak of the market was in 1990 when proceeds from pearl sales were estimated at more that five million US dollars (Tint Tun, 1998).

The supply of wild oysters is erratic so pearl oysters are produced by the hatchery at Pearl Island (Maung Bo, 2004). Myanmar researchers have studied various aspects of the biology of *P. maxima* including anatomy (Tint Tun, 1984), spawning and rearing conditions (Kay Thwe Htwe, 2006, 2007; San San Aye, 2007; Tint Tun, 1989) and the cause of mass mortalities (Tint Tun, 2000).

All fishing is prohibited within three nautical miles of Pearl Island according to DoF Notification No. 7/93 (29 July 1993).

ECHINODERMS

Echinoderms include sea cucumbers, sea stars and sea urchins, discussed below. Other echinoderms that are less economically important, including feather stars and brittle stars, are not reviewed here but have been documented by Duncan *et al.* (1889b).

Sea Cucumbers

Sea cucumbers, also called bêche-de-mer, are slow moving, cylindrical invertebrates with few defenses. Each species has a particular habitat preference and species can be found in deep and shallow waters and on coral reefs, in seagrass beds and along the intertidal zone. Nearshore, intertidal species are particularly easy to collect and often contribute to small-scale, artisanal fisheries in developing countries. Deeper water sea cucumbers are collected by free divers or divers using compressed air. They also use simple fork-ended rods to collect the animals.

Sea cucumbers are boiled, dried (by sun or smoke) and exported mainly for use in Chinese cuisine or traditional medicines. Fishing takes place in the dry season from October to April when the waters are calmer and, presumably, when it's easier to dry the product. In Taninthayi, there are buying centres in Myeik and Kawthoung and the products are sent to Yangon or Ranong in Thailand (Figure 3), and then on to major markets in Japan, Korea, China and Singapore. The species range in value with the highest-valued species fetching as much as 100,000 kyats/kg of dried weight, which is currently worth more than USD100. *Holothuria scabra* and *H. lessoni* are common, high-valued species. A species of *Synaptula* fetches the highest price but is rare. In Myanmar, sea cucumbers are found most commonly in the Myeik Archipelago where the species composition has been well-documented (Bo Bo Kyaw, 2012; Nang Mya Han, 2012; Yee Yee Htwe, 2009). There are fewer animals along the Rakhine Coast (Nang Mya Han, 2012), which supports a smaller fishery.

Although sea cucumbers have been harvested in Myanmar for centuries, the industry has undergone rapid expansion with the opening of Chinese markets in the 1980s and there was a boom in the industry in the 1990s in Southeast Asia, including Myanmar (Tint Tun *et al.*, 2008). The increasing demands of the market and lack of regulations have led to uncontrolled exploitation of the resource. Sea cucumber stocks have been overexploited in many countries and some have placed temporary moratoriums on their harvest to allow populations to recover. It is unclear what the current level of harvest pressure and status of sea cucumber stocks are in Myanmar.

Sea cucumber species that are found in Myanmar are summarized in Appendix 15. Two species identified within this study are new records for Myanmar.

The Crown-of-thorns starfish is abundant on reefs in the southern Myeik Archipelago. The impact of this destructive species in Myanmar has not yet been assessed.

Sea Urchins

Sea urchins are collected by local people for their roe (eggs), which can be eaten.

Starfish

Starfish are dried and sold at souvenir shops. The crown-of-thorns (*Acanthaster planci*) is a destructive species of starfish that eats corals and has ravaged reefs in the region. They are abundant on reefs in southern Myeik Archipelago at all of the sites marked on Figure 6 (this study) but no one has yet studied their impact in the country.

Echinoderm species of Myanmar, except sea cucumbers, are listed in Appendix 16.

CORALS

Of the 267 species that Veron (2000) shows likely to exist in Myanmar waters, most of these species (99.6%) are shared with the nearby Coral Triangle, a region of high coral diversity that encompasses the waters of Indonesia, Malaysia, the Philippines and Papua New Guinea (Veron *et al.*, 2009). A smaller, but still substantial, portion of these coral species (75.7%) is also shared with the Western Indian Ocean. Only one coral species is shown as inhabiting only the waters edging the Bay of Bengal: *Acropora rudis* is believed to be limited to a belt through Thailand, Myanmar, India, Sri Lanka and the Maldives (Veron, 2000).

Due to various influencing factors such as evolutionary history, circulation patterns and habitat diversity, coral species-level diversity is highest within the Coral Triangle. In areas stretching north of this region, diversity drops off but still remains high when compared with other regions of the world. It is unsurprising, therefore, that species diversity is higher in the lower latitudes of Myanmar.

A number of studies have documented the species composition of corals at various coastal sites in Myanmar (Aung Phyo Oo, 2012; Cherry Aung, 2009a, b; Han Ni Linn, 2010; Mya Than Tun & Tint Tun, 2002; Obura *et al.*, 2014; San San Win, 1993; Soe Tint Aung, 2010; Tin Myo Aung, 2010; War War Soe, 2008; Zarni Ko Ko, 2012). Coral taxonomy and species distributions are evolving areas of knowledge. OBIS (Web site) shares data on record distributions and WoRMS (Web site) provides information on the changing taxonomy and the currently recognized species names. Drawing from these sources, an updated list of predicted and known coral species compositions of the three coastal areas is summarized in Appendix 2. Only corals of the Class Anthozoa are included. Coral Families are also being rethought taxonomically based on genetic analyses. There are disputes concerning the reclassification of species within the traditional Families Faviidae, Mussidae, Oculinidae, Pectiniidae, Poritidae, and Siderastreidae. We chose to organize this species list using the

same Family groupings as most of the coral researchers referenced to allow for minimal confusion.

Note that this list contains only those species that the authors of this report are confident likely occur in Myanmar's waters. It does not include all the species identified by researchers since, for some of these species, the current known distribution does not include Myanmar or nearby waters, or we were unable to find references that confirmed their distributions. Further study will help to confirm species identifications, broaden this list and reveal range extensions. Also note that, with evolving taxonomic understanding, many species once known under one name have been reclassified and are now known under another name and some species have been combined. Records include 356 species of 76 genera.

Among these records, we include 42 species that have not yet been encountered in the studies conducted in the country but whose known ranges indicate that they likely occur in Myanmar's waters. Conversely, eight species that were identified by at least one Myanmar researcher but whose ranges reported in Veron (2000) and data records included in the OBIS database do not include Myanmar, have been considered probable and may represent range extensions for those species. Further collections and taxonomic studies will therefore likely confirm range extensions and document additional species in Myanmar.

Species distributions within Myanmar are influenced not only by latitude but also by sedimentation patterns. *Favites* spp., *Favia* spp., *Pocillopora* spp., and *Pavona* spp. seem to be tolerant of high sedimentation while *Symphyllia* spp., *Lobophyllia* spp., *Galaxea* spp., *Montipora* spp. and *Pories* spp. are prominent in areas with lower levels. *Millepora* spp., *Heliopora* spp., *Hypnopora* spp. and *Turbinaria* spp. are found in clear waters (Cherry Aung, 2009a). Very few species are found in the Ayeyawady Delta region since sedimentation levels are so high.

Alterations in the physical parameters that corals experience can cause colonies to die and species distributions to change over time. If sedimentation levels increase in portions of the Rakhine or Taninthayi coasts, corals will die off and species biodiversity will decrease. Of particular concern in Myanmar is coral bleaching which appears to becoming widespread. Coral bleaching occurs when increases in sedimentation, temperature, pollution or disease stress corals causing them to eject the symbiotic algae living in their tissues. Without these algae, corals turn white and die. Bleached corals were seen on the reefs of the Myeik Archipelago in 2013 by research divers (U Zau Lunn, *pers. comm.*), SCUBA divers (tourism survey, Appendix 18) and researchers of this study. The degree and distribution of bleaching have not yet been adequately assessed.

There are two main ways corals are directly, physically damaged in Myanmar — blast fishing and trawling. Blast fishing became common in Myanmar in the 1990s and is still witnessed in the Myeik Archipelago (see tourism surveys in Appendix 18). Trawlers that operate too close to shore and over reefs can drag up corals, killing the colonies and destroying the habitat. Corals that have been broken apart and pulled to the surface cannot survive. Plus corals have a very slow growth rate, so pieces remaining after severe damage often cannot grow fast enough before seaweeds outcompete them for space.

SEAWEEDS

Algae is a diverse group of aquatic plants that range in size from microscopic, unicellular organisms to multicellular forms that can be as large as giant kelps which can reach 65 m long. The term "seaweed" is a non-formal term that refers to macroscopic, benthic marine algae. The chlorophyll compositions in the tissues of seaweeds influence their colours and these colours are used to classify the seaweeds into three major groups — red algae, green algae and brown algae.

Seaweeds have been well-documented in Myanmar. Some short species lists were complied by Martin (1871) and then it was more than 100 years later when the next scientific attention was given to them (Kyi Win, 1972). We collected more than 60 reports, publications and theses that include seaweeds as their foci. These are summarized in Appendix 17. There have been a number of recent, detailed reviews for each of the major groupings, including habitats and their local and global ranges (Mya Kyawt Wai *et al.*, 2009a; Soe Htun *et al.*, 2009a; Soe Htun *et al.*, 2009c; Soe Htun *et al.*, 2009d; Soe Htun *et al.*, 2009e; Soe Htun *et al.*, 2009f; Soe Pa Pa Kyaw *et al.*, 2009c). In some cases, known global distributions shared in the OBIS database implied that a species would not likely be found in Myanmar but multiple researchers in the country identified it. The authors of this report are unable to assess the probability of whether these records represent valid range extensions. Further study and review by qualified specialists will allow confirmation of various seaweed range extensions and data from Myanmar's seaweed specialists should be shared with global marine databases for inclusion.

Seaweeds are farmed commercially in many regions of the world. They are sold for food and for extractions of agar and carrageenan, both of which are gelling agents that have a range of uses. The technology used is wide ranging from the simple harvest and management of naturally occurring batches to complex culturing facilities. In Myanmar, people use low-technology approaches. Algae are attached to nets or strings that are fastened to a floating line tied between anchored poles that have been pushed into the bottom. This is done in shallow water near to the shoreline. Multiple lines can be arranged in rows (Win Htin, 1989).

Seaweed culture experiments have been conducted by Myanmar scientists since the 1960s and the first factory to produce carrageenan and agar from *Hypnea* and *Gracilaria* was established in 1979 in Thandwe District of the Rakhine Coast (Figure 2). *Enteromorpha*, *Catenella* and *Sargassum* have been grown to produce Japanese nori (Win Htin, 1989). Currently there is seaweed farming in the Myeik Archipelago. In 1989 it was estimated that at least 1,500 tons of dried, raw seaweed was produced in Myanmar each year (Win Htin, 1989).

Sometimes important habitats such as mangrove stands and seagrass beds are removed in nearshore areas to create seaweed farms, though this impact is likely small in Myanmar. One of the main potential problems with seaweed farming is that the lack of protocols and restrictions can lead to the introduction of commercially interesting species from elsewhere that may become invasive with a range of difficult-to-predict impacts including uncontrolled growth. For example, a commercially desirable seaweed species, *Eucheuma denticulatu*m, was introduced for farming in Kiribati. It has since grown out of control and is choking coral reefs, fouling fishing nets and impacting fish catches (New York Times, 2008). Similarly, the alga *Kappaphycus alvarezii* was introduced for commercial cultivation in in southern India and within a decade it smothered the reef of the Gulf of Mannar Biosphere Reserve (Chandrasekaran *et al.*, 2008) and the same genus is spreading rapidly over reef in Kane'ohe Bay in Hawaii (Conklin & Smith, 2005).

There is currently no legislation regulating aspects of seaweed culture in Myanmar (Mya Than Tun *pers. comm.*).

STAKEHOLDERS

GOVERNMENT

Department of Fisheries (DoF)

The Department of Fisheries (DoF) falls under the Ministry of Livestock, Fisheries and Rural Development (MLFRD) and is responsible for the management of Myanmar's fisheries and coastal resources. As of 2010, livestock and fisheries accounted for 7.6% of the country's gross domestic product (Department of Fisheries, 2010). The DoF has a number of directorates including Capture Fisheries, Aquaculture, Research and Development and Administration. The DoF national headquarters are based in Nay Pyi Taw and States/Regions and Districts have smaller administrative offices.

BOX 7 | The 6 key responsibilities that guide DoF activities:

- The conservation and rehabilitation of fishery resources
- The promotion of fisheries research and surveys
- Collection and compilation of fishery statistics and information
- Provision of fisheries extension services;
- Supervision of fishery sectors
- Ensuring the sustainability of fishery resources

(Myanmar Ministry of Livestock and Fisheries, 2008b)

The DoF issues licenses, evaluates sites for aquaculture, produces fingerlings for sale to the aquaculture industry, advises the MLFRD on fisheries matters, acts as an inspection body for trade, administers auctioning of Leasable Freshwater Fisheries and water bodies for aquaculture, provides training, and communicates with stakeholders.

A Monitoring, Control and Surveillance programme for fishery management generates statistics that are published in national reports by the Myanmar Ministry of Livestock and Fisheries (2008a, b); Myanmar Ministry of National Planning and Economic Development (2010) and the Department of Fisheries (2010) and are shared with global organisations who can collate and share the data more broadly (see FAO, 2013).

The DoF is involved in research programmes on endangered species and ecosystems such as marine turtles and Irrawaddy dolphins. They oversee some conservation areas such as the marine component of the Thamihla Kyun Wildlife Sanctuary and the Khaing Thaung Island Reserve Forest and work closely with stakeholders to manage these areas. They are also the management authority for two Shark PAs.

The DoF performs the role of Myanmar's scientific authority for aquatic species for CITES.

Department of Environmental Conservation (DEC)

In 2012, the Ministry of Forestry was reorganised to become the Ministry of Environmental Conservation and Forestry (MOECAF) reflecting a growing awareness of the importance of addressing environmental issues in the country. Soon after a new department, the Department of Environmental Conservation (DEC) was created. The DEC will be responsible for an ambitious range of activities including implementing environmental conservation policies, designing and implementing monitoring programmes, prescribing environmental quality standards, conducting activities relating to waste management and conducting Environmental Impact Assessments (EIAs).

Forest Department (FD)

The Forest Department (FD) also falls under MOECAF and is responsible for the management of forests, including mangrove forests, though some mangroves are ceded to the DoF for possible aquaculture development. The FD is also the key implementing agency for the designation and management of protected areas in the country. The FD is Myanmar's management authority, enforcement authority, and scientific authority for non-aquatic species for CITES.

© Andy Mann/3 Strings Productions

Ministry of Education (MoE)

Myanmar's Ministry of Education (MoE) oversees all formal education in the country from basic to higher education. The ministry supervises the implementation of educational programmes and sets educational policies.

Ministry of Hotels and Tourism (MoHT)

Myanmar's Ministry of Hotels and Tourism (MoHT) oversees and legislates aspects of Myanmar's burgeoning tourism sector. MoHT has worked with NGOs, such as WCS, on developing ecotourism activities.

Navy of the Union of Myanmar

The naval branch of Myanmar's armed forces operates more than 122 vessels. The Navy patrols Myanmar's water and enforces maritime laws for the country. The navy is mandated to enforce various marine fisheries laws, in particular those relating to offshore fishing.

State/Region Governments

Six of Myanmar's 14 States and Regions border the eastern edge of the Bay of Bengal and many of their peoples have livelihoods connected with marine systems. These are: Rakhine State, Ayeyawady Region, Yangon Region, Bago Region, Mon State and Taninthayi Region.

RESEARCH AND EDUCATION

Myanmar Academy of Arts and Science

The Myanmar Academy of Arts and Science was created in 1999 under the MoE and is comprised of experts from across a range of academic fields. The academy conducts regular seminars and publishes the Journal of the Myanmar Academy of Arts and Science.

Universities

The country's first Marine Biology programme was established in 1973 at the University of Mawlamyine in Mon State on the Taninthayi Coast. It was upgraded to become a Marine Science Department in 1986. Most of the senior marine scientists in the country were trained here. The university has a field station at Setse. This station was established in 1985 as a high-tech aquaculture facility through funding from the UNDP project, "Strengthening of Marine Science Teaching at Moulmein College" (UNESCO, 1985). By 1995, the university was no longer able to support the high maintenance and

electrical costs and the facility began its decline into disrepair. Tanks are now cracked and water filtration and pumping systems are inoperable so aquaculture research can no longer be conducted. However its facilities are still used by the university as a field station that hosts undergraduate field courses.

Two more marine programmes stemmed from the original at Mawlamyine, which allowed research to expand to other areas of Myanmar's coast. Pathein University in the Ayeyawady Region has a Marine Science Department with a field station on the Rakhine Coast just south of Shwe Thaungyan. This station has good access to a range of marine habitats and hosts seven to ten day courses at the end of each semester. Myeik University, also with a Marine Science Department, is on the Taninthayi Coast, close to the islands of the Myeik Archipelago. It has a large Marine Science Museum and hopes to host the future Marine and Coastal Resources Research Centre.

Yangon is the oldest university in the country and its students and staff conducted many of the original studies of Myanmar's marine life. It is home to Diamond Jubilee Hall that contains the national depository of PhD Theses. Other universities have Zoology, Botany and Chemistry departments whose staff and students are able to conduct marine-related research, including the Universities of Bago, Dagon, Dawei and Sittwe.

Phuket Marine Biological Centre (PMBC), Thailand

The Phuket Marine Biological Centre (PMBC), established in 1966, is one of the older and more established marine research centres in the region. Regional workshops are often hosted there and, in recent years, Myanmar scientists have had the opportunity to attend training workshops at the centre. In 2010 and 2012, Myanmar teachers have attended courses on coral and marine mammals, respectively.

LOCAL NON-GOVERNMENTAL ORGANIZATIONS (LNGOS)

Marine Science Association, Myanmar (MSAM)

The Marine Science Association, Myanmar (MSAM) is open to all graduates of marine science in Myanmar. MSAM's work focuses on research, conservation and the sustainable development of coastal areas. MSAM collaborates with Marine Science Departments at Mawlamyine, Pathein and Myeik Universities along with marine science alumni. MSAM collaborated with WCS Myanmar in producing this review.

Myanmar Environment Rehabilitation-conservation Network (MERN)

The Myanmar Environment Rehabilitation-conservation Network (MERN) is a network of 16 Myanmar LNGOs with a range of foci and experience. MERN projects are implemented jointly by member NGOs and focus mainly on environmental conservation and rehabilitation linked with community development relating to food security and livelihood development. In the marine realm, MERN instigated the Coastal Livelihood and Environmental Assets Restoration in Rakhine (CLEARR) project to improve mangrove forests and livelihoods in villages in Thandwe District. In 2012, MERN co-hosted the workshop "Conservation and Sustainable Management of Coastal and Marine Ecosystems in Myanmar" alongside IUCN and MFF.

Biodiversity and Nature Conservation Association (BANCA)

The Biodiversity and Nature Conservation Association (BANCA) conducts a range of projects relating to nature including surveys, watershed development, establishing forest plantations and access to drinking water. BANCA partnered with Europe Conservation Switzerland (ECoSwiss) for a series of studies of Lampi Island and is currently partnering with FFI to conduct surveys of coral reefs in the Myeik Archipelago.

Livelihoods and Food Security Trust Fund (LIFT)

The Livelihoods and Food Security Trust Fund (LIFT) aims to improve the food and livelihood security of poor and vulnerable people in Myanmar. LIFT works in areas where food poverty is high, including the Ayeyawady Delta and Rakhine State.

Rakhine Coastal Region Conservation Association (RCA)

The Rakhine Coastal Region Conservation Association (RCA) conducts awareness raising for the conservation, rehabilitation and sustainable use of Rakhine's mangroves and conservation of marine turtles. It also works on community forestry activities and wild elephant conservation.

Rakhita

Rakhita is an environmental NGO based in the Rakhine Coast. In recent months, it has run a five-day land-planning workshop in Ngapali of the Thandwe District (Figure 2).

Forest Resource Environment Development and Conservation Association (FREDA)

The Forest Resource Environment Development and Conservation Association (FREDA) is an NGO with a focus on the forestry sector of Myanmar. FREDA is composed of more that 400 members including foresters, botanists, agronomists, zoologists, veterinary scientists, hydro-geologists, engineers, timber businessmen, journalists and artists. In the marine realm, FREDA has worked with communities that rely on mangrove resources.

Myanmar Environment Institute (MEI)

The Myanmar Environment Institute (MEI) provides training courses in environmental science and management and in conducting EIAs.

The Ecosystem Conservation and Community Development Initiative (ECCDI)

The Ecosystem Conservation and Community Development Initiative (ECCDI) works on sustainable forest ecosystem management, which includes the establishment of mangrove plantations.

INTERNATIONAL NON-GOVERNMENTAL ORGANIZATIONS (INGOS), BILATERAL AID AGENCIES, AND INTERNATIONAL ORGANIZATIONS

Wildlife Conservation Society (WCS) Myanmar

The Wildlife Conservation Society (WCS) was the first international conservation NGO to work in Myanmar, establishing a program in 1993. WCS's Myanmar Program has memorandums of understanding with both MOECAF and MLFRD and has worked with the DoF for over ten years to develop and manage the DoF's first freshwater protected area, the Ayeyawady Dolphin Protected Area on the mainstream Ayeyawady River upstream of Mandalay. The WCS Myanmar Program has worked with MSAM and the WCS Global Marine Conservation Program to conduct this review.

Fauna and Flora International (FFI)

Fauna and Flora International (FFI) works in Myanmar through collaborations with the local NGO, BANCA. Projects have focused on conducting biodiversity assessments and conservation status reviews and strengthening local civil society organisations to protect biodiversity through protected area management. The NGO recently conducted surveys of reefs in the Myeik Archipelago using the protocols of another international NGO, Reef Check.

Istituto Oikos

Istituto Oikos, an Italian NGO that works in developing countries to promote environmental conservation as tool for socio-economic development. In 2011, Oikos has worked in collaboration with the FD and BANCA at Lampi Marine National Park and recently published a detailed review of Myanmar's Protected Areas (Isituto Oikos, 2011).

International Union for the Conservation of Nature

© Katherine Holmes/WCS

(IUCN)

IUCN hopes to start working in Myanmar in the near future alongside the BOBLME Project and in collaboration with MFF on a multi-stakeholder coalition to support and guide national and international conservation efforts in the Myeik Archipelago. In 2012, IUCN, MFF and MERN hosted the workshop "Conservation and Sustainable Management of Coastal and Marine Ecosystems in Myanmar".

Japan International Cooperation Agency (JICA)

The Japan International Cooperation Agency (JICA) has worked in Myanmar on a range of projects relating to health and economic development. Relevant to the marine realm, the organisation collaborated with MOECAF on the Ayeyawady Delta Integrated Mangrove Rehabilitation and Management Project.

Mangroves for the Future (MFF)

Mangroves for the Future (MFF) promotes investment in coastal ecosystems for sustainable management and uses mangroves as a flagship ecosystem because of their important roles in coastal livelihood and security. MFF has not yet started to work in the country but, as one of its "outreach countries", Myanmar is invited to regional events and meetings. MFF plans to work alongside IUCN on coastal management issues in Myanmar. In 2012, IUCN, MFF and MERN hosted the workshop "Conservation and Sustainable Management of Coastal and Marine Ecosystems in Myanmar".

The Wetlands Alliance

The Wetlands Alliance is an association of agencies that view wetlands and aquatic resources as an entry point for poverty alleviation initiatives in Southeast Asia. It engages with partner organisations in Thailand, Vietnam, Laos and Cambodia and, in recent years, has visited projects in Myanmar with an aim to establish a presence in the country.

WorldFish

In September 2012, Worldfish and the DoF commenced the four-year project "Improving Research and Development of Myanmar's Inland and Coastal Fisheries (MYFish)". The project is first gathering data on the state of fisheries and aquaculture in Myanmar and then plans to develop management capacity and help develop fisheries and small-scale aquaculture to increase the productivity of this sector.

Worldview Myanmar Limited

Worldview Myanmar Ltd. Is a nonprofit organization affiliated with Worldview International Foundation. The NGO's mission includes assisting Myanmar's sustainable growth through sharing practical approaches and providing information to policy makers on sustainable development. The organization is currently focusing on projects focusing on nectar production from Nypa palm, tissue culture for orchid production, solar light testing and mangrove rehabilitation.

REGIONAL BODIES

Bay of Bengal Large Marine Ecosystem (BOBLME) Project

The BOBLME Project engages all eight nations that rim the Bay of Bengal, namely the Maldives, India, Sri Lanka, Bangladesh, Myanmar, Thailand, Indonesia and Malaysia. The project aims to lay the foundations for a coordinated programme of action designed to improve the lives of the coastal populations through improved regional management of the Bay of Bengal environment and its fisheries. The executing agency is the FAO Regional Office for Asia and the Pacific, based in Bangkok, and the FAO is also involved in project components directly relating to fisheries and resource management. Principal funding is from the Global Environment Facility (GEF), the government of Norway, the Swedish Internal Development Agency, FAO, participating governments and the National Oceanic and Atmosphere Administration (NOAA). The project had a total estimated budget of USD 31 million for an initial period from September 2008 to August 2013, though a no-cost extension has been requested to an anticipated date of March 31, 2015. The National Inception Workshop was held in Myanmar in early 2010 and since then Myanmar experts have attended and contributed to a number of workshops focusing on a range of topics including policy reviews, trans-boundary issues, Hilsa fisheries, fisheries and aquaculture assessments, fishery statistics, coastal management, responsible fisheries training and climate change. Partners to the project who are active in Myanmar include the Government of Myanmar, IOSEA, SEAFDEC, and WorldFish. A vast number of project reports are available through its website

(Bay of Bengal Large Marine Ecosystem Project, Web page).

Food and Agriculture Organization (FAO) Asia-Pacific Fishery Commission (APFIC)

APFIC is a regional fisheries body of the FAO. APFIC was founded in 1948 and merged with the Indian Ocean Fisheries Commission in 1999. Its main objective is "to promote the full and proper utilization of living aquatic resources of the Asia-Pacific area by the development and management of fishing and culture operations and by the development of related processing and marketing activities in conformity with the objectives of its members". The commission reviews the state of resources and makes recommendations, carries out programmes and conducts training to increase the efficiency and sustainability of fisheries and aquaculture. Myanmar is among its 21 members. Many of the statistics collected by Myanmar's DoF on the country's production from marine and freshwater fisheries and aquaculture are processed, housed and shared through the APFIC and FAO (see FAO, 2013). Myanmar is in FAO Fishing Area 57 and the sub-area 57.1 that encompasses all of the Bay of Bengal.

Southeast Asian Fisheries Development Center (SEAFDEC)

Myanmar is one of eleven SEAFDEC member countries, joining in 1999. The Center, established in 1967, is mandated "to develop and manage the fisheries potential of the region by rational utilization of the resources for providing food security and safety to the people and alleviating poverty through transfer of new technologies, research and information dissemination activities". The center supports training activities, technical assistance, research and publications relating to fisheries development in the region through four technical departments: the Training Department, the Marine Fisheries Research Department, the Aquaculture Department and the Marine Fisheries Resources Development and Management Department. The center also aims to be a unified voice for fisheries issues in the region (Southeast Asian Fisheries Development Center, 2013).

Women living in coastal areas often make a living through processing fish. This woman from Chaung Tha is spreading fish to dry in the sun.

© Katherine Holmes/WCS

Ice factories provide this essential commodity for offshore fishing boats that may fish far from shore for many days.

FISHERS AND SUPPORTING SECTORS

Gleaners

A number of marine resources can be caught close to shore. This is often done by women and children who are able to collect marine life for food when the tides and timing is good. Octopuses, oysters, seashells and chitons can be gleaned from water pools and rock faces. These can be eaten at home or sold. We met enterprising children collecting sardines and anchovies around the boats at landing sites, which they sold to local households.

Nearshore Fishers

Nearshore fishing includes a range of gear and target fish. Traps are used to catch lobsters. Push nets are used to catch wild shrimp. Cast net fishers catch small fish in shallow waters. Spear fishermen may walk or use a boat to target rich reef habitats. The small catches would feed families that night. In areas such as Thandwe, where there are other employment opportunities, nearshore fishing can be supplementary to primary sources of income. For more serious fishermen, small crews may head out for the day to target a lucrative fishery and other species are caught opportunistically. For example, we interviewed four fishermen on a 25ft boat with a longtail style engine in Thandwe who showed us their typical one-day catch. They caught seven spiny lobsters (their target), which were sold to a broker for export and supplemented the catch with groupers, triggerfish, butterfly fish, one sea cucumber and egg cowries. The DoF estimated there were 13,788 powerboats and 17,054 boats without engines used for fishing in Myanmar in 2010 (Department of Fisheries, 2010).

Offshore Fishers

Offshore fishers in Myanmar include longliners that target pelagic fish all along the coast. Squid fishers are common along the Taninthayi Coast. Large commercial boats with crews of several men head out on multi-day trips and use lights to lure squids. Bottom trawlers' primary targets are prawns or finfishes. Anchovy and sardine fishers using purse seine nets are common off areas of the Rakhine Coast. The DoF estimated the number of offshore vessels in Myanmar at 2205 in 2010 (Department of Fisheries, 2010).

Foreign Fishers

Myanmar's fisheries law has explicitly allowed for the use of their marine resources by neighbouring countries. According to official data, from 2004 to 2011, 250 to 300 foreign boats per year fished in Myanmar bringing in an estimated USD12 million per year in taxes. However, fishing rights for foreign boats expired on March 31, 2014 and the parliament banned foreign fishing vessels starting in April 2014 in an effort to reverse declines in fish stocks (Ocean Biogeographic Information System,

© Katherine Holmes/WCS

Local boat owners of Rakhine State have adapted boats so they can take tourists out on fishing and snorkeling trips.

Web page). According to MFF, in the 2013-2014 fiscal year, an estimated 40 foreign fishing vessels were operating in the country (Ocean Biogeographic Information System, Web page).

Fish Processors

A huge range of people are involved in fish processing. These include women and men who clean and dry fish and invertebrates along the coasts. Techniques, approaches and scale of these operations vary by the level of organisation involved and the species being processed.

Semi-nomadic Ethnic Peoples

The peoples known in Myanmar as the Salone or Moken are part of a larger group of semi-nomadic Austronesian peoples who live along the coasts and islands of the Andaman Sea, including the islands of the Myeik Archipelago. They are highly dependent on marine resources, which they collect and catch for food and barter with at markets. Some of the Moken are still nomadic and live on hand-made wooden boats. During the rainy season, they shelter in temporary stilt houses on the lee side of islands and repair their boats.

Myanmar Fishery Federation (MFF)

The Myanmar Fishery Federation (MFF), a national level organisation with a membership of over 700 companies and 27,000 individuals, is mandated to encourage and promote fishing industries. MFF aims to promote the socio-economic life of member entrepreneurs and fishery communities, share information on economic policies and fishery technologies and advocate on behalf of the fishing industry, among other objectives. There are nine associations under MFF that deal with particular industries, namely, shrimp, fish, exporters, aquaculture feed, marine fisheries, freshwater capture fisheries, crabs, eels and ornamental fish.

SUPPORTING INDUSTRIES

Industries that support the needs of fishers are indirectly dependent on marine resources. Carpenters, gear suppliers, ice factories and cold storage facilities are all critical players in the fishing industry in Myanmar. As of 2010, there were 11 and 19 cold storage facilities and 39 and 26 ice plants in Rakhine State and Taninthayi Division, respectively (Department of Fisheries, 2010).

Exporters

Exporters connect local fishers with foreign markets. A wide range of marine products is exported from Myanmar. These include live lobsters and groupers, prawns, shrimps and crabs.

TOURISM STAKEHOLDERS

Marine Activities Tourism Operators

Currently there are only two commercial SCUBA diving operations in Myanmar. The Myanmar Andaman Resort on Macleod Island in the southern Myeik Archipelago is a remote resort with dive facilities. Another dive shop, Ngapali Water Sport

Center in Thandwe opened in February 2012 (Figure 2). Both of these shops are co-owned by A-One Diving, a Thai-owned company based in Ranong, Thailand (Figure 3).

The Rakhine Coast area has not been promoted as a dive destination so currently few divers head to the area explicitly for diving. The Ngapali shop tends to run three to four snorkeling or dive trips per week in the high season (November to the end of April). The manager is concerned about the state of the reefs and is trying to encourage fishermen to not drop their anchors on the reef or throw rubbish in the ocean.

Dive tourists primarily visit Myanmar on live-aboard dive boats of businesses based in Thailand. They enter the country in Kawthoung and primarily visit the southern islands of the Myeik Archipelago and the Burma Banks.

Local entrepreneurs have also developed small-scale businesses that take tourists out to nearby spots for fishing and snorkeling excursions.

Tourism Service Providers

At government-sanctioned tourism areas, a range of businesses that serve tourists have been developed by local people as well as foreign partnerships. At Ngapali Beach, Chaung Tha and Ngwesaung (Figure 2) where local economies are intimately tied to tourism, seafood (both locally caught and brought in from other areas) dominates restaurant menus, long strips of hotels line the beach and shops sell souvenirs including items made from marine products. Other sites along Myanmar's coast also support some tourism but currently it is less marine-focused.

Curios Producers

There is a large network of people within Myanmar that create and sell curios made from marine products. These are sold mainly at tourist destinations. These include both areas of the country where there is intensive marine-related tourism such as Ngapali Beach, Chaung Tha and Ngwesaung (Figure 2) as well as at many of the temples and other destinations in the country. They are sold to both national and international visitors.

A woman in Chaung Tha makes necklaces and other crafts from shells to sell to tourists.

LEGAL FRAMEWORK

Myanmar's "Fisheries Law" was first created in 1905 and updated in 1954. This law was repealed in 1989 and substituted by the "Law Relating to the Rights of Foreign Fishing Vessels".

Three other fishery laws followed, namely the "Aquaculture Fisheries Law" in 1989, the "Myanma Marine Fisheries Law" in 1990 (amended in 1993) and the "Freshwater Fisheries Law" in 1991.

The introduction of trawling in the coastal waters of Myanmar in the 1980s led to conflicts between traditional fishermen and trawling operations that necessitated amendments to the "Law Relating to the Rights of Foreign Fishing Vessels" to provide a more comprehensive legal framework to manage fisheries. Amendments in 1993 strengthened the legal framework relating to marine and freshwater fisheries, aiming to:

- Provide more revenue through fishery taxation
- Protect natural fishing resources
- Ensure equitable allocation of fishery resources
- Obtain accurate fishery data
- Strengthen activities to reduce conflict among fishing communities

Mangroves are impacted by legislations around forestry management. The "Forest Law" of 1992 replaced the colonial-era "Burma Forest Act and Rules" of 1902.

The "Protection of Wildlife and Wild Plants and Conservation of Natural Areas Law" of 1994 repealed the "Wild Life Protection Act" of 1936. This law focuses on the protection and conservation of wildlife, endangered species and habitats. Wildlife is classified under three categories of protection under section 15 of the law, namely (i) completely protected, (ii) normally protected and (iii) seasonally protected. Section 37 of this law makes it an offence for any person to kill, hunt or wound a completely protected wild animal without permission; possess, sell, transport or transfer a wild animal or any part thereof without permission; or export a wild animal or plant without the permission of the Director General.

All of these laws are reviewed in detail by Tsamenyi (2011).

The "Myanmar Environment Conservation Law" was recently enacted in March 2012. Recently drafted Environment and Conservation Rules prescribe the duties of the National Environment Conservation Committee, the MOECAF and the Environmental Conservation Department; and outline environmental standards, the processes surrounding EIAs and guidelines.

Various regulations have been issued by the Government of Myanmar within the main body of particular laws and in the form of notifications.

Marine Turtles

Under the 1905 Fishery Law it was forbidden to trespass in turtle nesting areas without official consent (11/1905). Under Agriculture Notification No. 1/2005 (1924), it is forbidden to trespass within three miles of a turtle hatching area and turtle eggs cannot be eaten. Notification No. 2/93 specifies that all turtles caught accidentally must be released, marine turtles cannot be consumed, TEDs must be used on trawling gear in all fishing areas and damaged fishing gear cannot be thrown into the ocean.

Crabs

Notification No. 8/94 established size limits for crabs for export (length 6.15 cm) and controls their trade under section No. 35 of the Aquaculture Law. Notification 9/94 defines measuring systems for crabs and sets limits.

Prawns

Notification No. 3/95 prohibits trade gravid marine penaeid species of prawns, which cannot be caught, exported, sold, killed or kept in captivity unless permitted by the Director General of DoF. If accidental catch occurs, they should be released immediately. Species under protection are *Penaeus*

monodon, P. indicus, P. merguiensis , P. semisulcatus and P. japonicus. Another notification, No. 2/95, outlines similar regulations for important freshwater prawns, Macrobrachium rosenbergii and M. malcolmsonii malcolmsonii.

Lobsters

It was reported in a local newspaper that a coastal area near Anansan Village in Thanbyuzayat Township, Mon State, has been designated as a lobster refuge by the DoF.

Hard Clams

Hard clam collection is prohibited during their reproductive season, 1 January to 31 March, every year at two areas totaling 20 acres at the confluence of Kye River and Tapochaung River in Pulaw Township, Myeik District, Taninthayi Region (Figure 3). Small clams of less than 20 mm cannot be collected at all in the areas.

Groupers and Sea Bass

Notification No. 2/2006 states that the capture, killing, transportation, storage and retention of and any disturbance relating to groupers bearing eggs is prohibited during their reproductive season, 1 July to 30 September, every year. This includes species of the genera Epinephelus, Cromileptes and Cephalopholis. The same regulations are applied for sea bass (*Lates calcarifer*) from 1 January to 31 March.

Sharks

DoF Notification No. 2/2004 established two no-shark-fishing areas around Dome Kyun and Lampi Islands of the Myeik Archipelago in the Taninthayi Region (Figure 6, numbers 120 and 121). The larger, northern area is 11,734 km^2 and the smaller area around Lampi Island is 1705 km^2.

Whale Sharks

Under Notification No. 2/2001, it is forbidden to catch, harass, kill, possess, sell, buy, export or transport Whale sharks (Rhincodon typus) anywhere in Myanmar waters. If accidental entanglement in fishing gear occurs, the animal must be released immediately.

© Katherine Holmes/WCS

Fishermen will often abandon damaged fishing gear. This is illegal because the gear can continue to catch and kill fish. This fish trap was left on a reef in the Myeik Archipelago.

Pomfret

To minimize the bycatch of small pomfret of less than 100 grams, Notification No. 2/2013 legislates a closed season for use of bag nets from 1 April to 31 May every year.

Offshore Fishing Closed Season

On 30 March 2013, Notification No. 3/2013 was created, declaring that offshore fishing vessels were prohibited from fishing during the height of shrimp reproductive season from 1 June to 15 July of 2013. However, within a month of issuing the law the DoF announced that 75% off registered fishing vessels could continue fishing during the closed season.

Fishing Gear

Some fishing gears that are destructive to the environment and marine resources are banned. Banned gear includes pair trawling; electric fishing; fishing using poisons, chemicals and explosives; and push nets. Fishery Inspectors are authorized to seize banned gear under the "Law relating to the Fishing Rights of Foreign Fishing Vessels 1989" and the "Myanmar Marine Fisheries Law".

Mangroves

Under the "Forest Law" of 1992, the Ministry of Forests (now MOECAF) can declare public lands as Reserved Forests or Protected Public Forests for mangrove conservation.

Community Co-Management

A major shift toward community management of forest resources occurred in the mid 1990s with the issuance of the Community Forestry Instructions by the FD in response to widespread forest degradation and increased demand for forest products and services. The document guides participatory resource management and impacts management activities in mangrove and other forest systems (Kyaw Tint *et al.*, 2011).

In the fisheries sector, a joint FAO and DoF project in Bogale Township in 2011 allowed village fishery societies to organize the management of 16 tender fisheries. This close cooperation of the DoF and the State Government is setting a valuable precedent for fisheries co-management in the country that is unlike what has been seen in other sectors. Currently there is no particular provision for fisheries co-management in Myanmar's existing fisheries laws nor regulations relating to community participation in fisheries management.

This project has enabled communities to gain management authority to parts of the fishery through the declaration of some fishery areas as Special Management Areas (SMAs) by the DoF. In these areas, all laws, notifications, directives, rules, and regulations still apply but additional management measures may be introduced by communities who have been given rights to manage fishery resources within their boundaries. The DoF may declare that these SMAs are governed by communities that are being assisted by a formal project (Livelihoods and Food Security Trust Fund, 2013).

The term "fisheries co-management" implies that communities and the State work together versus other commonly used terms such as "community fisheries management", which implies that communities are solely responsible for the management of their fisheries, within the boundaries of the law.

Closed Fishing Areas

DoF has restricted fishing in various fishing grounds, including portions of A20, B15, B20, B10 of the Rakhine Coast; ten nautical miles from the shore line of C3 and C4 in Ayeyawady Region; in two fishing grounds (D23 and in D28 on the east side of the centreline between North Moscos island and Middle Moscos island) in Mon State (Figures 3 and 5); and in two fishing grounds (E11 and E17) in Taninthayi Region (Figure 5).

Notification No. 5/94 declared a no-fishing area around Lampi Island of Bokpyin Township of Taninthayi Region (latitude 10°41.5´N to 10°59.3´N and longitude 98°4.9´E to 98°18.3´E). Fishing is prohibited from the low water line to two nautical miles out. Notification No. 7/93 declared a no-fishing area around Pearl Island of Bokpyin Township, Taninthayi Region (latitude 11°10´N to 10°59.3´N and longitude 98°12´E to 98°22´E). Notification No. 1/99 declared a no-fishing area in Kawthoung Township of Taninthayi Region (latitude 10°00´N to 11°00´E and longitude 95°17´E to 98°30´E). Two Shark Protected Areas have been declared in the Myeik Archipelago of the Taninthayi Region under Notification No. 2/2004 (see Figure 3).

Protected Areas

In Myanmar, protected areas are usually legally pronounced through Notifications. Protected areas that have a marine component and have formal protected status through the national government are as follows:

1. Moscos Island — PA Notification No. 188/28 (September 1, 1928)
2. Thamihla Kyun Wildlife Sanctuary — PA Notification No. 289/70 (1 December 1970)
3. Meinmahla Kyun Wildlife Sanctuary — PA Notification No. 91/93 (5 January 1993)
4. Lampi Marine National Park — PA Notification No. 40/96 (20 August 1996)
5. Two Shark Protected Areas — PA Notification No. 2/2004 (5 May 5 2004)

Management Zones

Under international law, Myanmar's Exclusive Economic Zone (EEZ) extends to 200 nautical miles from shore. Under the current national laws, fishing activity in Myanmar is controlled by a licensing and registration system designed to control both vessel and gear types. Two fishing zones have been established through a licensing scheme whereby zones are designated for specific fishing gear, classes of fishing vessels and ownership. This is an attempt to provide equitable allocation of resources and reduce conflicts between traditional and commercial fishers. Commercial fishing vessels, such as trawlers and fish purse seiners, are prohibited from fishing within five nautical miles of the Rakhine Coast and ten nautical miles of the Ayeyawady Delta and Tanintharyi Coasts.

Trawlers often fish illegally in nearshore waters, which can lead to conflicts between inshore and offshore fishers. A recent proposal urging the government to oversee and prohibit trawlers operating in the inshore fishing areas was submitted to the fifth regular session of Myanmar's House of Nationalities (called the Amyotha Hluttaw) on 22 October 2012 and was approved by the parliament with a majority vote (Kyaw Tint *et al.*, 2012b).

Stakeholders have pointed out that the definition of coasts within the "Myanma Fishery Law" does not adequately address whether island coasts are included along with the mainland coasts in defining these zones. The law defines "Myanma Marine Fisheries Waters" as "the waters along the sea coast of Myanmar from the high tide mark toward the open sea, the waters on the seaside of the straight line drawn from one extreme end of one bank to the extreme end of the other bank of the river and creek mouths, the waters from the said high tide mark to the end of the Exclusive Economic Zone" and the inshore and offshore zones are divided by their distance from the sea coast – five nautical miles off the Rakhine Coast and ten nautical miles off the Ayeyawady Delta and Tanintharyi Coasts. The "Territorial Sea and Maritime Zones Law" of 1977 provides straight baselines that "have been drawn between fixed points on the mainland, on islands or rocks" and includes a schedule with GPS points. The map of this baseline is provided in the document "The Law of the Sea; Baselines: National Legislation with Illustrative Maps" (United Nations Office for Ocean Affairs and the Law of the Sea, 1989) and it clearly encompasses all of the islands of the country.

Fishing Licenses

Under the "Myanma Marine Fisheries Law", inshore fishers, people intending to collect other marine products for sale and sport fishing businesses are required to obtain a license from the officer in charge of the DoF of the respective Township. Offshore fishers similarly need a license from the DoF of the relevant State or Region. Foreign fishers are allowed to access Myanmar's resources under the Foreign Investment Law and need to apply for a license to the Director General of the DoF.

Fisherman Registration

Every fisher must be registered and anybody working, living or staying on a fishing vessel must have a fisher's registration card.

Fishing Vessels

Under the "Myanma Marine Fisheries Law", building of or importing a fishing vessel from abroad for offshore fishing requires prior approval from the DoF.

Foreign Fishers

Myanmar's fisheries law allows for the extraction of marine resources by neighbouring countries under the "Foreign Investment Law" and the "Law Relating to the Fishing Rights of Foreign Fishing Vessels". Fishing rights for foreign boats expired on 31 March 2014 and the parliament banned foreign fishing vessels starting in April 2014 in an effort to

reverse declines in fish stocks.

Importing and Exporting

The "Fisheries Notification on Prohibition of Fish Importing" lists fish species that may not be imported, exported, sold or kept in captivity without permission of the Director General of the DoF.

Output Control

Currently, there are neither Individual Transferable Quotas nor Total Allowable Catch regulations in Myanmar's fisheries sector.

Taxes

Import tax on shrimp exported to China was removed at the beginning of 2004 to promote trade between Myanmar and China. Shrimp exports to Japan from Myanmar are taxed at more than 20% by value of total shrimp exports from Myanmar.

International Conventions

Myanmar is legally bound by a number of international conventions that relate to conservation, including:

- London Amendment to the Montreal Protocol (London, 1992) — Accession 1993
- Convention for the Protection of the World Cultural and Natural Heritage (Paris, 1972) — Acceptance 1994
- Convention on Biological Diversity (Rio de Janeiro, 1992) — Ratified 1994
- CITES (Bonn, 1979) — Accession 1997
- United Nations Framework Convention on Climate Change (New York, 1992) — Accession 2003
- Convention on Wetlands (Ramsar, 1971) — Ratified 2005
- Amendment to the Montreal Protocol (Copenhagen, 1994) — Accession 2009

Table 4. List of Marine Key Biodiversity Areas in Myanmar. Source: Wildlife Conservation Society (2013) and Wildlife Conservation Society (Web page). See Figure 6 for a map of the areas.

Map #	KBA Name	National Protection Status	Authority	State / Region	Key Species
110	Oyster Island		?	Rakhine	Hawksbill turtle, Green turtle
106	Nantha Island		?	Rakhine	Hawksbill turtle, Green turtle, Loggerhead turtle
104	Myebon		GA	Rakhine	Irrawaddy dolphin, Spotted dolphin (?), Green turtle, Olive ridley turtle
30	Kyaukphyu (Wunbike)		FD	Rakhine	Hawksbill turtle, Green turtle, Olive ridley turtle, Mangrove spp.
97	Manaung Kyun		GA	Rakhine	Dugong, Hawksbill turtle, Green turtle, Loggerhead turtle
98	Maw She		GA	Rakhine	Dugong, Hawksbill turtle, Green turtle, Loggerhead turtle, Olive ridley turtle
107	Ngwe Saung		?	Ayeyawady	Dugong, Hawksbill turtle, Green turtle
79	Great Coco Island		GA	Ayeyawady	Leatherback turtle, Green turtle, Loggerhead turtle, Olive ridley turtle
127	Thamihla Kyun Wildlife Sanctuary		NWCD	Ayeyawady	Irrawaddy dolphin, Green turtle, Loggerhead turtle, Olive ridley turtle
91	Khaing Thaung Island	Reserve Forest	DoF	Ayeyawady	Olive ridley turtle, Mangrove spp.
87	Kadonkani	Reserve Forest	FD	Ayeyawady	Mangrove spp.
86	Kadongalay Island		DoF	Ayeyawady	Irrawaddy dolphin, Green turtle, Loggerhead turtle, Olive ridley turtle
37	Meinmahla Kyun Wildlife Sanctuary	Notified Protected Area — Terrestrial	NWCD	Ayeyawady	Irrawaddy dolphin, Hawksbill turtle, Olive ridley turtle, Salt water crocodile, Mangrove spp.
78	Gayetgyi Island		DoF	Ayeyawady	Irrawaddy dolphin, Green turtle, Loggerhead turtle, Olive ridley turtle
119	Pyindaye	Reserve Forest	FD	Ayeyawady	Olive ridley turtle, Salt water crocodile (?), Mangrove spp.
102	Moscos Wildlife Sanctuary	Notified Protected Area — Terrestrial	FD	Taninthayi	Indo-Pacific finless porpoise, Hawksbill turtle, Leatherback turtle, Green turtle, Olive ridley turtle, Mangrove spp.
105	Myeik Archipelago		GA	Taninthayi	Irrawaddy dolphin, Dugong, Indo-Pacific finless porpoise, Hawksbill turtle, Leatherback, Green turtle, Mangroves spp., Whale shark
121	Shark Protected Area	Notified Protected Area — Aquatic	DoF	Taninthayi	Unknown
120	Shark Protected Area	Notified Protected Area — Aquatic	DoF	Taninthayi	Unknown
77	Burma Banks		?	Taninthayi	Leopard shark
32	Lampi Marine National Park	Notified Protected Area — Terrestrial & ASEAN Heritage Park	NWCD	Taninthayi	Dugong, Hawksbill turtle, Leatherback turtle, Green turtle

PROTECTED AREAS AND MARINE CONSERVATION AREAS

Myanmar's Protected Area system was introduced in the 1980s and the "Protection of Wildlife and Wild Plants and Conservation of Natural Areas Law" was enacted in 1994. The Myanmar "Forest Policy" of 1995 set a target of 5% of total land area to fall under protection and MOECAF increased that goal to 10% in 2000. Protected areas are often legally designated through Notifications.

There are several different designations of existing natural areas under the Wildlife Law including "Scientific Reserve", "National Park", "Marine National Park", "Nature Reserve", "Wildlife Sanctuary" and "Geo-physically Significant Reserve". However, the distinction on the ground is not always clear and the degree of enforcement is variable.

Some conservation areas with marine coverage have been established, however, there is a considerable gap of representation of marine ecosystems, when compared with terrestrial systems in the country (Wildlife Conservation Society, 2013). Of the 43 FD officially-recognized protected areas in Myanmar in 2011 (Isituto Oikos, 2011), only four (9%) have marine elements. Two additional marine conservation areas, both Shark Protected Areas with no additional distinguishing names, have since been created.

Of the four protected areas with marine elements reviewed by Isituto Oikos (2011), all also have a terrestrial aspect to them and at least three are considered "Notified Protected Areas – Terrestrial" (Wildlife Conservation Society, 2013). The Meinmahla Kyun Wildlife Sanctuary of the Ayeyawady, established in 1993, is in a low, flat delta area that supports abundant mangroves and is administered by the Nature and Wildlife Conservation Division (NWCD) of the FD. Thamihla Kyun Wildlife Sanctuary, established in 1970 in the Ayeyawady, is governed by the NWCD. However, there is a strong marine component to the conservation activities that take place there and the DoF oversees those undertakings (Wildlife Conservation Society, Web page). The sanctuary supports populations of Green, Loggerhead and Olive ridley turtles as well at the Irrawaddy dolphin. Moscos Island Wildlife Sanctuary of Taninthayi Region, established in 1928 and under the jurisdiction of the FD, supports Indo-Pacific finless porpoises and four of Myanmar's five marine turtle species, but mainly the terrestrial portion of the island is under protection (Isituto Oikos, 2011).

The fourth, Lampi Marine National Park, is administered by the NWCD and is also an ASEAN Heritage Park. Established in 1996, it encompasses Lampi Island, several smaller nearby islands and the surrounding waters, totaling 274 km^2. The seabed between the island and the mainland is no deeper than 24 m. The shoreline is rocky with bays, inlets and sandy beaches. The inland forest is mainly an evergreen forest and the coastal habitats include mangroves, seagrass beds and coral reefs. Lampi Island is particularly well-studied with field surveys between 2008 and 2010 led by the Myanmar Environmental Project managed by Istituto Oikos and BANCA with support from ECoSwiss (Beffasti, 2010; Myint Sein & Bo Ni, 2009; San Tha Tun *et al.*, 2008; Saw Han Shein *et al.*, 2010; Tint Swe *et al.*, 2011; Tint Tun, 2010, 2011; Tint Tun & Aung Myint Oo, 2008; Tint Tun & Bendell, 2010; Tint Tun *et al.*, 2008). However, there is no management plan in place for Lampi and its settlements of approximately 3,000 people (Associated Press, 2014). Dynamite fishing, encroaching trawlers, poor waste management, and a range of unsustainable practices have degraded the area. Istituto Oikos is working to developing ecotourism opportunities, enact a draft management plan, and train park rangers who were posted there by the FD starting in 2013 (Associated Press, 2014).

The two Shark Protected Areas are in the Myeik Archipelago and are extremely large at 1706 km^2 and 11,734 km^2 (Figure 6). Little is known about what key conservation species are found in these waters or the effectiveness of these reserves.

It is well-recognized that Myanmar's existing protected areas are susceptible to overexploitation of biological resources and there is a need to improve management effectiveness (National Biodiversity Strategy and Action Plan, 2011). Myanmar Agenda 21, the blue print for natural resource management in the country, includes strengthening protected area management as an important measure for biodiversity conservation (National Biodiversity Strategy and Action Plan, 2011).

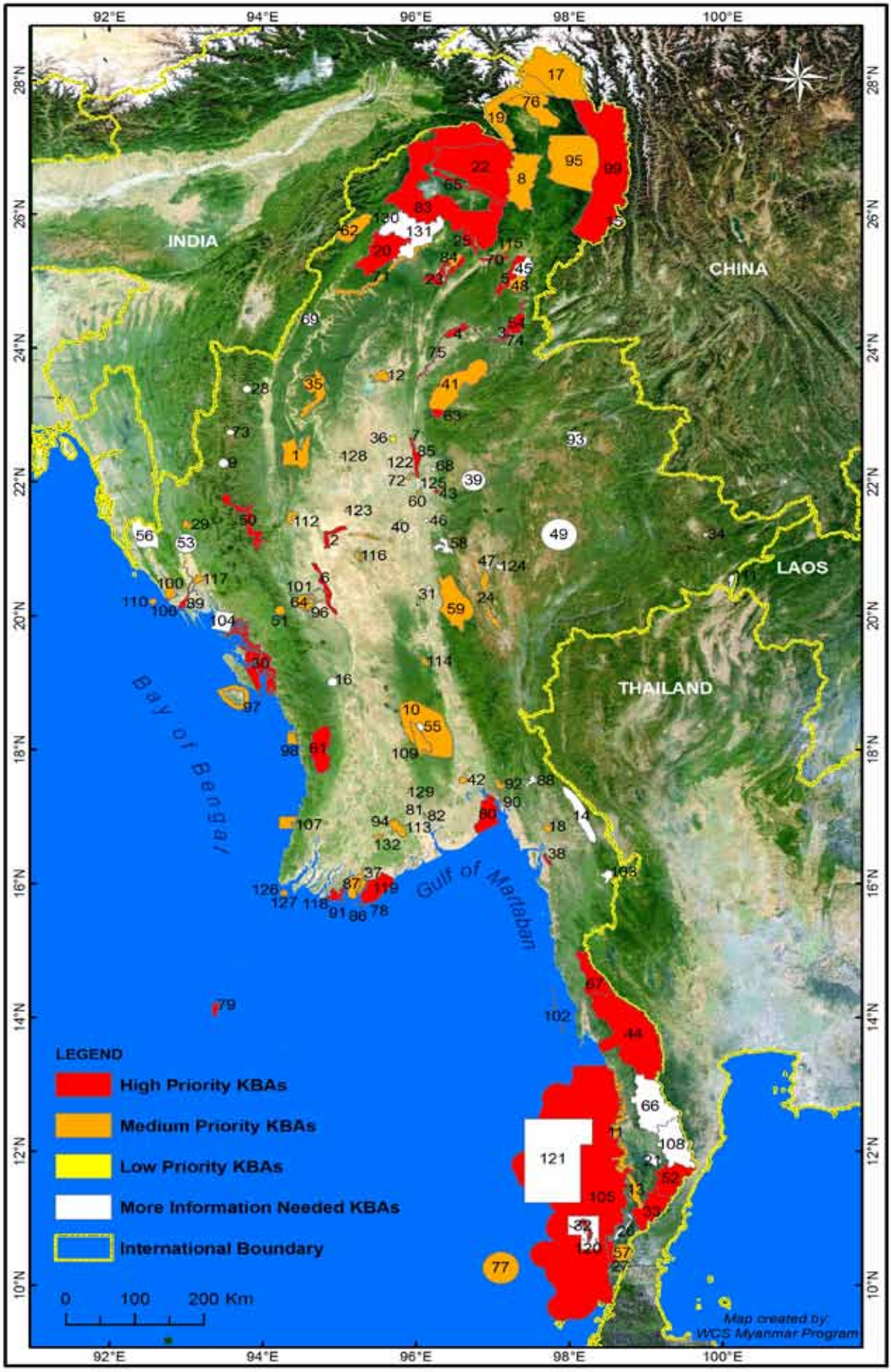


Figure 6. Key Biodiversity Areas of Myanmar. Source: Wildlife Conservation Society (2013). See Table 4 for the details on each area.

Under the Convention on Biological Diversity's (CBD) new Strategic Plan for Biodiversity 2011-2020, Aichi Target 11 calls for parties to protect "10 percent of coastal and marine areas, especially areas of particular importance for biodiversity and ecosystem services". However, protected areas can range greatly in their level of effectiveness (Sciberras *et al.*, 2013). The area under protection alone gives no indication of whether areas are "effectively and equitably managed, ecologically representative and well connected systems … and integrated into the wider landscapes and seascapes" (CBD, 2010).

The effectiveness of any protected area is based both on ecology (e.g. the responses of species and habitats to management actions) and human behaviour (e.g. how well people are able to implement the management strategies). No critical assessment of the effectiveness of the Shark Protected Areas has yet been conducted, however anecdotal information suggests that enforcement and adherence to regulations are low. Similarly, the Lampi Marine National Park does not yet have effective adherence to conservation measures. No management or operational plan was prepared when Lampi was designated in 1996 and, since then, human settlements inside and outside the protected area have grown considerably (Isituto Oikos, 2011). Recognizing this issue, in 2009 Isituto Oikos and BANCA initiated consultations among stakeholders with the intention to launch a process for developing a management plan. The project conducted workshops and focus group discussions leading to the workshop "Conservation and Sustainable Management of Lampi Marine National Park" in 2010 (Isituto Oikos, 2011). To our knowledge a management plan has not yet been prepared and approved. Although fishing is, technically, prohibited within the park boundaries, subsistence and commercial fishermen use a range of gear and target a variety of resources inside. Plus fishing practices that are illegal throughout the country, such as offshore fishers targeting near shore areas and fishing with dynamite, are also reported to occur within park boundaries (Isituto Oikos, 2011).

The FD has been using a management approach that combines environmental management with economic development in community forestry areas, including mangrove areas.

All of Myanmar's protected areas were included within the MBCIV (2013) assessment of Key Biodiversity Areas (KBAs). KBAs accommodate different management responsibility including government, private, community-led and joint management. All current KBAs which are wholly or partially marine are listed in Table 4 along with their national status, responsible management authority, size, priority as determined through the MBCIV process, location and the key species of conservation priority that they support. Numbers in Table 4 match the numbering on the map of KBAs, Figure 6.

TOURISM

Marine-related tourism to date has been limited within Myanmar and will likely transform dramatically in the years to come. In recent years, the primary seaside areas designated for tourism have been Chaung Tha, Ngwesaung and Ngapali beaches, all along the Rakhine Coast (Figure 2). The Ministry of Hotels and Tourism (MoHT) has begun preparing for a surge in tourism through developing their Responsible Tourism Policy (Ministry of Hotels and Tourism, 2012) and their Policy on Community Involvement in Tourism (CIT) (Ministry of Hotels and Tourism, 2013).

MoHT's Policy on CIT (2013) reflects the Ministry's stance that community involvement needs to be an integral part of a strategy for tourism promotion from local to national levels. The policy provides a framework for communities to gain access to tourism opportunities, action points and standards. An advisory committee is responsible for the amendment of the plans and for ongoing revision of existing activities. The policy specifically highlights the relationship of tourism with the promotion of the country's biodiversity and includes the sustainable management of the environment, natural resources and biodiversity conservation within the CIT service standards.

The MoHT has circulated directives to the private sector connected with coastal beach resorts with the aim to encourage sustainable development of coastal areas in line with MoHT laws; ensure sustainability of natural resources; preserve and conserve the environment; create job opportunities for local people; promote leisure and recreation for domestic and international tourists; and ensure the safety and serenity of tourists. MoHT guidelines include the following for building and operations that serve the tourism sector:

- Must be a minimum distance of five meters from the point of the highest tide
- Not to exceed two stories and not be higher than the tallest tree nor higher than ten meters above sea level
- No other massive construction is allowed along the beach areas
- Architecture and construction materials need to

© Katherine Holmes/WCS

A wide variety of seafood, locally caught as well as brought in from other areas of Myanmar, is sold at restaurants and hotels, especially in tourist areas such as Chaung Tha and Ngapali Beach, pictured here.

© Katherine Holmes/WCS

In tourist areas, local villagers sell wildlife curios such as these framed lobsters.

be especially chosen for the beach areas
- Allocate car-parking area with greenery
- Avoid the construction of high walls or fencing, which may block beach views.
- No digging of beach sand
- Land allowance of five meters for road construction within the hotel environs of every 500 meters for the accessibility of visitors to the beach areas
- Apply for license to operate hotel and beach resorts in accordance with the Procedures and Orders relating to the Myanmar Tourism Law
- Adhere to the rules and regulations issues by the MoHT regarding cultural norms, natural environment and environmental greening facilities, safety and security, child wise recreational activities, entertainment, emergency management, crisis communication, etc.

Chaung Tha and Ngwesaung, 20 km apart, are both in Ayeyawady Region, though outside of the delta area on the Rakhine Coast (Figure 2). Tourism developed after the construction of major bridges, allowing easier access (Kyu Kyu Khin, 2005). They are both five hour drives from Yangon and, as such, tourism is dominated by domestic tourists. The areas were chosen for tourism development based on their expansive beach areas and proximity to Yangon. Most tourists visit the area primarily for land-based activities such as walking and biking the beaches, eating seafood and shopping.

Ngapali beach of Rakhine State is targeted to both international and national tourists. Currently international tourists are granted visas limited to 28 days to explore Myanmar. Based on stakeholder interviews, these tourists tend to first travel to other primary tourist destinations in the country such as Bagan, Inle Lake, Mt Kyaiktiyo and various pagodas and may come to Ngapali at the end of a trip for only two to three days. These tourists tend not to explore the marine environment and instead spend the days relaxing on the beach and eating seafood. The area supports rich and diverse fisheries. Nearshore coral reefs are rocky with low coral cover and diversity and only a small fraction of tourists may take day trips to snorkel or fish. Recently (2012) a dive shop opened in the area allowing the first commercial access to SCUBA diving in the region. A more in-depth discussion of tourism specific to that area can be found in the Rakhine section of this report.

In recent years tourists have accessed the marine environments of southern Myanmar either through boat operators based in Thailand, or by staying at the isolated Myanmar Andaman Resort on Macleod Island in the Myeik Archipelago. The nature of tourism in this region is likely to change dramatically. The land border between Thailand and the Taninthayi area of Myanmar has recently become more open; investors have been purchasing land in the Myeik Archipelago for tourism developments; and those who have been diving in Thailand are increasingly interested in visiting the more isolated reefs of southern Myanmar.

Surveys of these tourists and tourism operators have revealed that, of marine animals, Myanmar's dive tourists most highly value seeing sharks, pelagic fish and reef fish. Dive tourists come to the country specifically because they expect to see sharks, rays, big fish, healthy reefs and beautiful landscapes as well as visit isolated locations (compared with other locations such as Thailand). However, in early 2013, sightings of sharks, rays and marine turtles were

rare. Total sightings could be averaged across the total number of dives or diver-hours of the survey respondents. Divers saw only one shark for every 28 dives (= one shark every 23.4 diver-hours); one ray for every 6 dives (= one ray every 5.0 diver-hours); and one marine turtle for every 31 dives (= one turtle every 25.5 diver-hours).

Dive guides who had worked in Myanmar in previous years and returning divers noted that populations of sharks, large fish and marine turtles were decreasing; there was more abandoned fishing gear and rubbish at the dive sites; and algal cover has been increasing. While first-time tourists also noted trash, evidence of blast fishing and abandoned fishing gear and were disappointed to see other dive boats at what they expected to be isolated spots.

However, despite these issues, most tourists said they would still recommend Myanmar as a dive destination. This is mainly to do with the underwater beauty, still healthy corals and a sense of isolation in a remote area. Demand for diving in Myanmar continues to grow. Thailand-based dive operators planned to expand the number of trips they offer to southern Myanmar in the 2013/2014 season. This will likely mean that their clients will see many other divers and dive boats in Myanmar and this will impact their clients' sense of isolation.

More details on findings from this survey can be found in Appendix 18.

HIGH PRIORITY MARINE CORRIDORS

In January 2012, over 80 of the country's environmental experts from civil society and government assembled to discuss the current state of Myanmar's biodiversity and used international criteria to identify and prioritize 132 Key Biodiversity Areas (KBAs). These sites are defined as areas holding significant populations of species of high conservation concern. Because connectivity is required to ensure that the full range of environmental services continue to function, these KBAs were grouped together within "conservation corridors". Fifteen conservation corridors were revised and updated taking into account connectivity among KBAs, safeguarding against the impacts of climate change and maintaining ecological processes, among other factors (Figure 7). These corridors allow for conservation planning that considers connectivity and resource impacts beyond the borders of nationally designated protected areas. Two marine conservation corridors were highlighted: The Taninthayi Marine Corridor and the Rakhine Marine Corridor (Wildlife Conservation Society, 2013).

RAKHINE MARINE CORRIDOR

Description

The Rakhine Marine Corridor extends along the entire coasts of Rakhine State and the western coast of Ayeyawady Region with a point extending out to and surrounding the Coco Islands (Figure 2). The corridor covers an area of 40,698 km^2. The continental shelf is narrow and deep and has a few inlets.

In the Ayeyawady Region, there are three townships with borders along the Rakhine Coast: Ngapudaw, Pathein and Thabaung Townships (Figure 2).

Rakhine State has 347 islands, Ayeyawady Region has 137 islands and Yangon Region has only 3, though not all of these islands are contained within the Rakhine Marine Corridor. The upper portion of the Rakhine coastline is shallow with deltas while further south it is generally rocky. The narrow continental shelf contains two large islands — Ramree and Man Aung (Figure 2).

Key Biodiversity Areas

Of the 132 KBAs in the country, there are six marine KBAs in the Rakhine Marine Corridor: Oyster Island, Nantha Island, Myebon, Kyaukphyu, Manaung Kyun and Maw She. Official protected status has not yet been established for any of these (Wildlife Conservation Society, 2013).

Stakeholders

Stakeholders that are relevant to marine conservation activities in the Rakhine Marine Corridor include most of the national level government bodies reviewed in the Stakeholder section of this report. Stakeholders of particular relevance to this area are the Rakhine State's and Ayeyawady Region's Government bodies; local fishers, processors and exporters who rely on fisheries; the Marine Biology Department of Pathein University; the Rakhine Coastal Conservation Association; Rakhita; hotels, restaurants, tour guides and curios shops that rely on the tourism industry; tourists; and local communities.

Fisheries

The major fish-landing site of the Rakhine Coast is at Thandwe (Figure 5). An important fishery along this coast is the anchovy and sardine fishery in the dry season.

Aquaculture

Prawn farming is particularly prevalent in Rakhine State. As of 2012, extensive prawn production systems were widespread with a range of farm sizes including local small, medium and large scale farms of up to 50 ha and very large, private investor farms of up to 200 ha. In recent years, Rakhine's prawn farms have experienced high mortality rates, and local farms' yields were low and even negative in some cases. This has led to the decline in prawn farming in recent years and, in some townships, more than 50% of the prawn ponds have been abandoned (Joffre & Moe Aung, 2012).

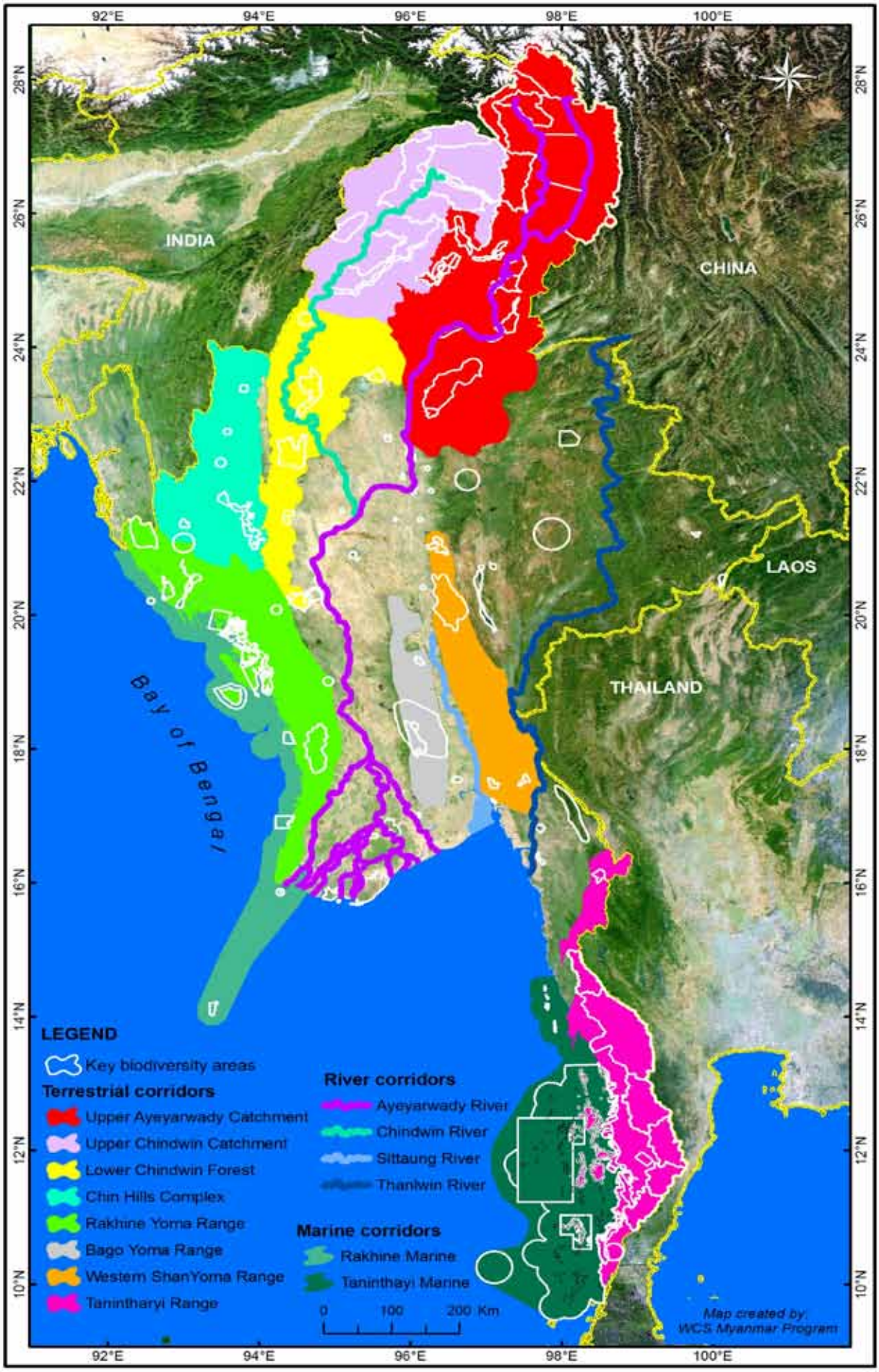


Figure 7. Myanmar's Conservation Corridors. Source: Wildlife Conservation Society (2013).

Habitats

Our classification and mapping of coral and seagrass, and mud flat habitats in the Rakhine Marine Corridor was accomplished using a Classification Tree Analysis with Landsat 8's visible and infrared bands (1-5) along with distinct training sites for both habitat classes in each study area.

Of the 40,698 km^2 of marine habitat contained within the Rakhine Marine Corridor, 912 km^2 were classified as coral (Figure 8). This is coverage is more than two times greater than coral coverage we initially calculated from the coarser Millennium Coral Reef Assessment data set (2010) from UNEP-WCMC. The Rakhine Marine Corridor's reefs are less developed and support lower biodiversity than those in the Taninthayi Marine Corridor but they still support important target fisheries such as reef fish and spiny lobsters.

Also within the corridor, we classified 1042 km^2 as seagrass (Figure 8), and only 14 km^2 as mud flats (not shown).

The 2011 USGS Global Distribution of Mangroves (Giri *et al.*, 2011a) data suggests that the Rakhine State supports 1381.7 km^2 of mangroves (Figure 8). Note that this coverage is only for the State and not the entire corridor. There are thin areas of coastal mangroves along the Ayeyawady's west coast within the Rakhine Marine Corridor that aren't included in this calculation. This is equivalent to 138,170 ha which falls between the "original" and "remaining" areas of Rakhine State's mangroves as reported by Maung Maung Kyaw (2012) (see Table 1). This discrepancy may be due to the USGS' approach not having the sensitivity and ability to distinguish levels of encroachment. Based on assessments of mangrove encroachment by Maung Maung Kyaw (2012), Rakhine had lost approximately 42% of its original mangrove habitat to encroachment by 2010. Mangrove conservation will be a growing issue in this region where the loss of ecosystem services provided by mangroves may be severe. Note that we did not conduct a new Classification Tree Analysis on mangrove habitats for this review.

Research Efforts

Our general understanding of the marine systems within the Rakhine Marine Corridor is stronger for the southern portion. Of the 368 theses we collected and documented, 266 included a geographic focus that we could determine to at least township level. Within the Rakhine Marine Corridor, thesis research focused around Sittwe Township in the north with nine theses (3.4%). The same number of theses were conducted in Thandwe Township (nine theses, 3.4%), which is centrally located. The greater proportion of theses focused on marine life in Pathein Township (38, 14.3%) and Ngapudaw Township (11, 4.1%) both of which are on the Rakhine Coast of the Ayeyawady Region (Figure 2). Other townships along the coast were the focus of only up to two theses. It is unsurprising that many student research projects have been conducted on the coasts and estuaries of Pathein Township since this is where Pathein University is based. Of the theses conducted in Sittwe, all were by students of the University of Yangon. Other studies and reports include northern areas of the coast but we have not been able to code every report for geographic coverage.

Tourism and fishery activities exist side-by-side along Ngapali Beach of the Rakhine Coast. Here fish are being dried on strips of blue mesh next to a hotel serving local and international tourists.

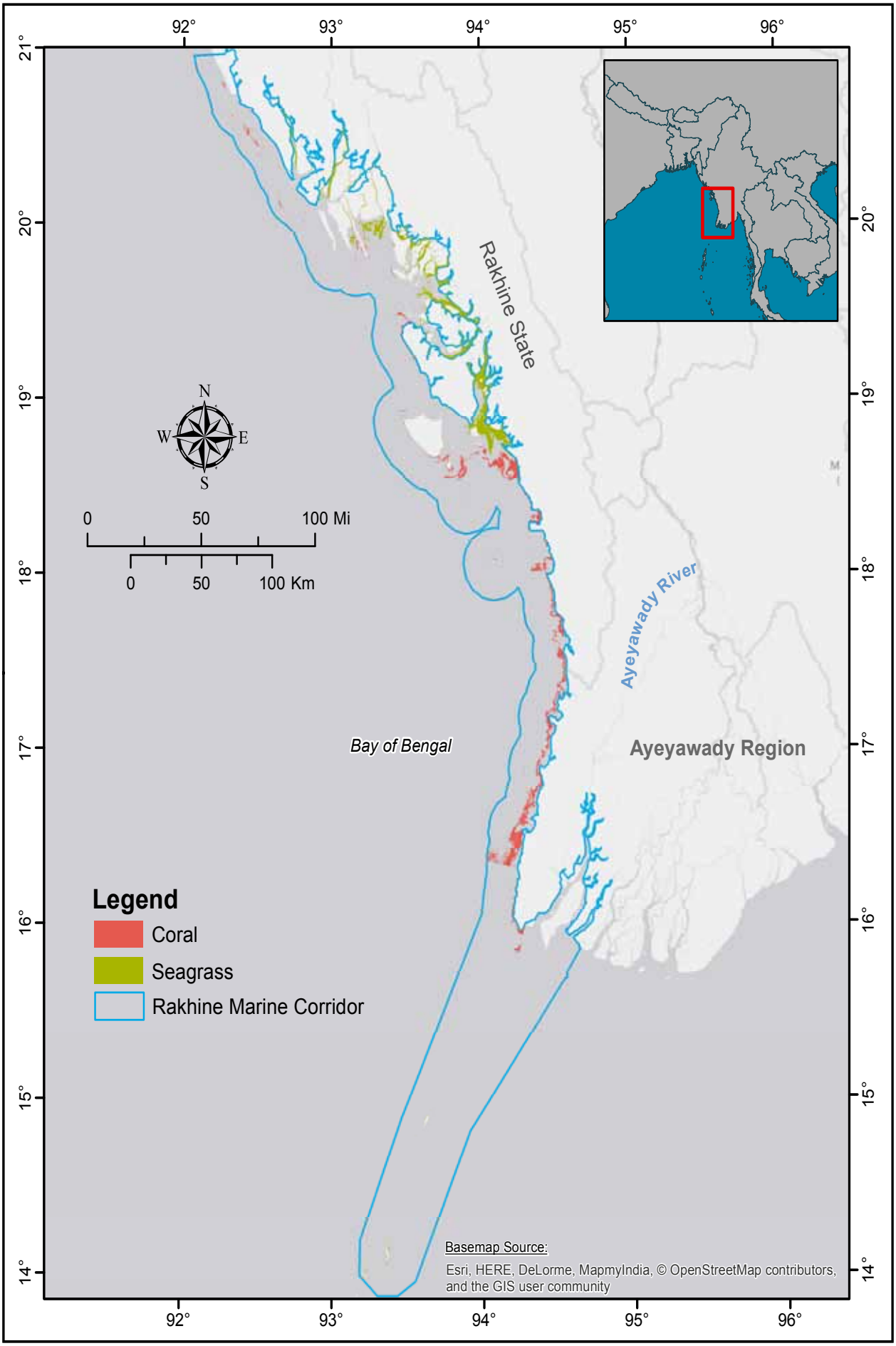


Figure 8. Distribution of coral reef and seagrass habitats within the Rakhine Marine Corridor.

Tourism

Currently marine tourism in the Rakhine Coast is divided into two regional pockets. In the Ayeyawady Region, Chaung Tha and Ngwesaung are the main seaside destinations near to Yangon (Figure 2). Tourism there is dominated by domestic tourists. Souvenir shops packed with t-shirts and crafts made from shell products line the town's streets, seafood is sold in almost every restaurant and beaches have been developed to support strips of hotels.

In Thandwe Township with Ngapali Beach (Figure 2), hotels similarly line the strips of beaches. As of 2013, there were approximately 17 hotels with two under construction. This translates to approximately 750 rooms and capacity for 1500 tourists. This area is targeted more toward foreign tourists but affluent Myanmar tourists also visit this popular destination. On average, most international tourists will only stay for two to three days. This is typically near the end of a busy vacation visiting Myanmar's crowded cultural destinations. Most foreign tourists visit this area to relax before returning home.

The boom in tourism and the growth of various economic opportunities has resulted in an influx of people from other regions to Thandwe. Over 30 years, two small schools, one with only 15 students, swelled into three with the largest serving over 600 students today (Stakeholder interviews).

Only a small subset of tourists at these destinations explore the marine environment. Local tour guides have developed flexible business models where they'll take tourists on full day or half-day boat trips that involve a combination of fishing, snorkeling and beach visits, depending on the tourists' interests.

Tourist fishing trips target mainly Mackerel, Barracuda and Yellowfin tuna. There was a sharp increase in the number of tour boats in 2010 as local operators reacted to the growing opportunity (Stakeholder interviews).

A SCUBA diving shop is now open in Thandwe but does not yet have much dive business. The Rakhine Coast is not an international dive destination, unlike nearby Thailand. Because of health and safety issues relating to breathing compressed air under water, most SCUBA divers will not dive for a full day before a flight. Therefore tourists who are visiting the area for only two days may only dive on the first day, which can be difficult to arrange. The business has identified some offshore dive locations that may support pelagic species of interest to divers and, in time, reports from their explorations will improve the understanding of marine life in the area. Research by visiting scientists will be enabled by the new access to SCUBA facilities.

At local restaurants, foreign tourists tend to favour prawns, squids and finfishes and many of these are harvested from other regions of Myanmar. The many small restaurants support a range in number of employees. Small restaurants typically employ two or more employees who, in turn, typically support three or four family members on their wages (Stakeholder interviews).

Tourists from different countries and of different ages tend to purchase different types of shell products. Single shells are popular with older foreign tourists. Chinese tourists purchase large shells and Europeans purchase those as well as polished shells and bracelets. Myanmar tourists purchase everything that they sell including decorations made out

Women and men in Thandwe District of the Rakhine Coast clean shells and make various crafts from them. These are sold locally as well as sent to business partners to sell at other tourist sites in the country.

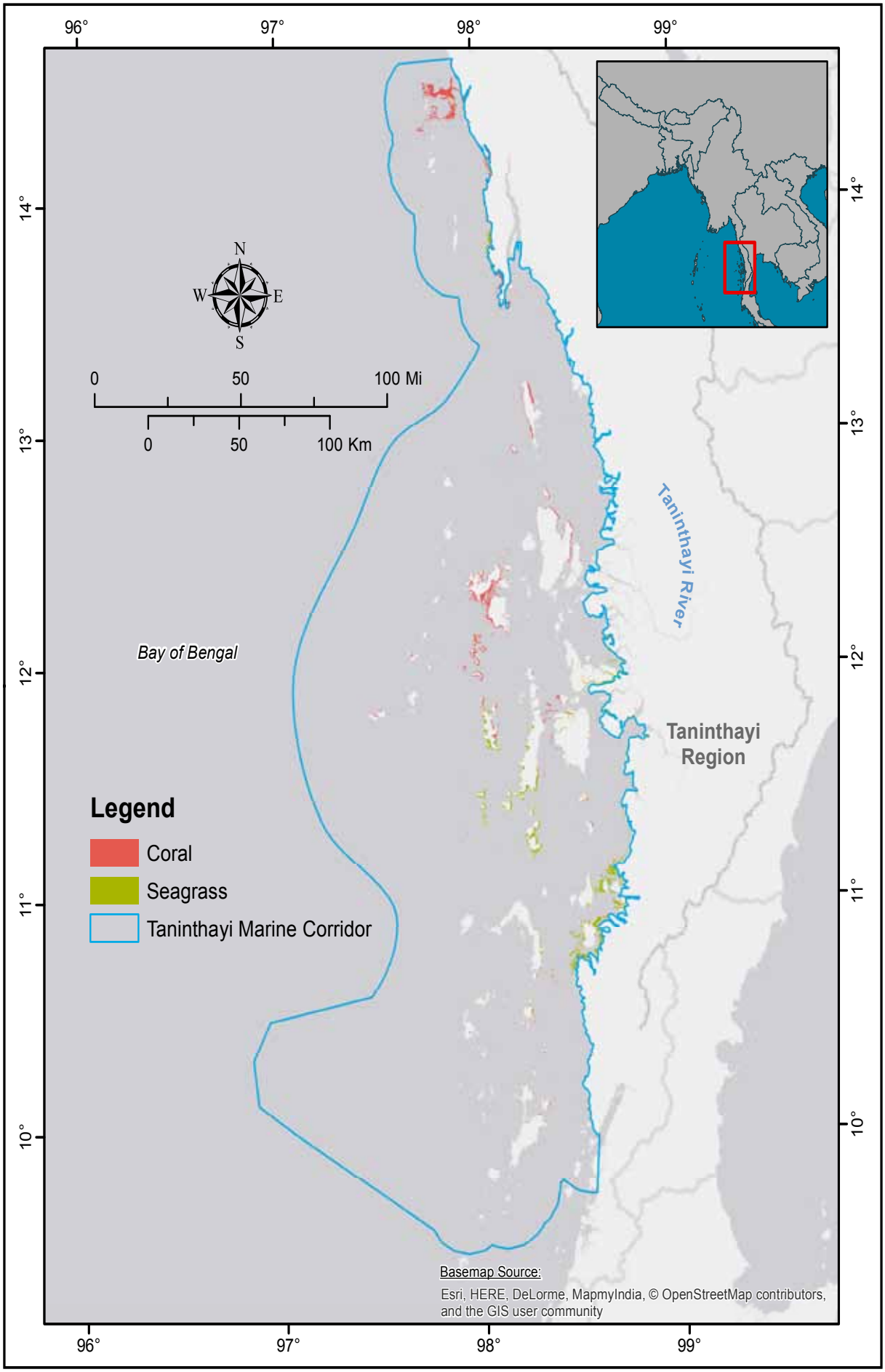


Figure 9. Distribution of coral reef and seagrass habitats within the Taninthayi Marine Corridor.

of many shells glued together. Some of the shells that are sold in the area are processed elsewhere and are sent back to the area for sale. For example, Trocha shells are polished in Yangon (Stakeholder interviews).

Many of the hotels are at or near to boat landing sites and the height of fishing activities and tourism coincide over the dry season period. Many tourists enjoy watching the activity of fishers in the early morning and mid-afternoon. Fish drying areas are often close to areas where tourists relax and the smell from the fish can be an annoyance for some tourists. In some stretches of beach, fish processing takes place about a five-minute walk from populated hotel beaches. Many of these processing areas are extremely unhygienic, sometimes with feces and rotting fish nearby. Surprisingly, the small number of tourists and hotel managers we spoke with did not express any concerns about this nor about issues around waste management.

TANINTHAYI MARINE CORRIDOR

Description

The Taninthayi Marine Corridor extends along virtually the entire length of Taninthayi Region in southern Myanmar and encompasses the Moscos Islands in the northern part of the Region, the numerous islands of the Myeik Archipelago and the offshore islands of the Burma Banks, totaling 1195 islands. The corridor covers an area of 65,780 km^2 (Figure 3). Note that this corridor is different from what is often referred to as the Taninthayi Coast. The Taninthayi Marine Corridor does not include the coastline of Mon State, further to the north. The Lampi Marine National Park and the Moscos Island Wildlife Sanctuary are within this corridor.

Key Biodiversity Areas

There are six KBA's encompassed within the Taninthayi Marine Corridor. Moscos Wildlife Sanctuary in the northern end is a Notified Protected Area that is mainly focused on terrestrial conservation but the islands also support marine life that includes priority species as outlined by the MBCIV, namely Indo-Pacific finless porpoises, Hawksbill, Leatherback, Green and Olive ridley marine turtles and mangroves (Wildlife Conservation Society, 2013). Lampi Marine National Park, within the Myeik Archipelago, focuses on both terrestrial and marine life and is home to dugongs, mangroves and Hawksbill, Leatherback and Green marine turtles. A Shark Protected Area encompasses Lampi Island and another similar, larger Shark Protected Area is further north (Figure 6). It is not yet known what of the key species these two reserves include in their areas but likely they are likely home to marine mammals, sharks and giant clams on the nearshore reefs. Other KBAs identified through the MBCIV stakeholder process include the entire Myeik Archipelago and the Burma Banks, which are not yet under governmental protection.

Stakeholders

Stakeholders that are relevant to marine conservation activities in this corridor include most of the national level government bodies reviewed in the Stakeholder section of this report. Stakeholders of particular relevance to this area are the Taninthayi's Regional Government bodies; the Marine Science Department of Myeik University; the businesses and people benefitting from the soon-to-be growing tourism sector; fishers, processors and exporters who rely on the areas rich marine resources; Thai fishers; SCUBA diving operators and tourists who enter from Thailand; the Moken peoples; and other local communities.

Fisheries

The major fish landing sites in the Taninthayi Marine Corridor are in Myeik and Kawthoung (Figure 5). Squid fishing and trawlers are the dominant offshore fishers and nearshore fishers are able to catch and harvest a wide range of species that rely on the rich mangrove, seagrass and reef resources of the area.

Habitats

Our classification and mapping of coral, seagrass, and muf flat habitats in the Taninthayi Marine Corridor was accomplished using a Classification Tree Analysis with Landsat's visible and infrared bands (1-5) along with distinct training sites for both habitat classes in each study area.

Within the 65,780 km^2 area of the Taninthayi Marine Corridor, 362 km^2 were classified as supporting coral habitat (Figure 9). This is coverage is approximately 100 km^2 more than the coral coverage we initially calculated from the coarser Millennium Coral Reef Assessment data set (2010) from UNEP-WCMC.

The reefs of the Taninthayi Marine Corridor are closer to the Coral Triangle, noted for high reef biodiversity and, unsurprisingly, these reefs are more diverse and richer than those of the Rakhine Marine Corridor. Major coral formations are found around some of the smaller islands, such as the Gregory Group of islands off the eastern side of Lampi Island. The region supports a range of coral formation types including fringing reefs; submerged pinnacles and seamounts; sheer and sloping walls; and boulder-strewn sand bottoms.

Also within the corridor, we classified 363 km^2 as seagrass habitat (Figure 9) and 238 km^2 as mud flats (not shown).

The 2011 Global Distribution of Mangroves USGS (Giri *et al.*, 2011a) data suggests that the Taninthayi Marine Corridor supports 2413.8 km^2 of mangroves (Figure 9). This is equivalent to 249,906 ha which is on the same order of magnitude but still much greater than the estimate of 195,103 ha made by Maung Maung Kyaw (2012). Based on assessments of mangrove encroachment by Maung Maung Kyaw (2012), the entire Taninthayi Coast had lost approximately 2.5% of its original mangrove habitat to encroachment by 2010. The main threat to Taninthayi's mangroves has been extraction for charcoal. The FD has intensified the protection through punishing illegal loggers and charcoal traders and it recently destroyed 204 charcoal furnaces (Kyaw Tint *et al.*, 2012a). These actions, along with current efforts by Myeik University to promote the importance of mangroves in the area, have ensured this ecosystem is not severely threatened compared to mangroves of other areas of the country. Small but pristine stands of mangroves are also found within the Lampi Marine National Park. Note that we did not conduct a new Classification Tree Analysis on mangrove habitats for this review.

Squids being dried in the sun.

Research Efforts

Our general understanding of the marine systems within the Taninthayi Marine Corridor is strongest around Myeik Township and the two townships to the south as reflected by studies by thesis students. Of the theses we collected that had an explicit geographic focus, 37 (13.9%) were in Myeik Township. And just to the south, Kyunsu and Bokpyin Townships both supported six (2.3%). This is unsurprising since these three townships are close to Myeik University and include the northern and central islands of the diverse Myeik Archipelago. Kawthoung Township, the furthest south in the country, has been the focus of only one geographically-explicit marine thesis. Launglon Township was the focal site of six (2.3%), all but one of these by students of the University of Yangon. Among the non-thesis reviews, articles and reports there have been a number that review systems or species of the Myeik Archipelago across multiple townships and many reports focused on Lampi Island of Bokpyin Township (Figure 3).

Tourism

Tourism in the Taninthayi Marine Corridor is dominated by dive tourism. These tourists' primary interests revolve around the marine realm and, as such, they have a strong knowledge of and concern relating to marine life and conservation. Marine related tourism is going to be expanding in the area in the near future with the development of resorts on islands in the Myeik Archipelago and a growing influx of tourists entering the region from Thai-operated dive businesses. Tourism will provide economic opportunities for some people in the region and increase some stresses. Nature-based tourists tend to appreciate pristine environments, yet the activities and businesses that support them while they're visiting will generate increased waste and the industry will create new challenges relating to land development and sewage management. Careful and thoughtful regulations of this industry in its infancy could lead to a model of sustainable tourism in the area.

THREATS AND ISSUES

Various meetings and a workshop conducted in Myeik as part of this review revealed the main priorities for marine research and conservation activities from the perspective of the staff of Myanmar's government bodies and academics. Attendees of the 7 June 2013 workshop are listed in Appendix 20. The primary threats, issues and recommendations with respect to the sustainability of marine resources that they identified in workshop discussions are listed in Appendix 19 and are incorporated here and in the recommendations section that follows.

Overfishing

Overfishing in Myanmar's waters is widely believed to be leading to stock decline for various target species. Workshop attendees listed a number of issues within the country that contribute to overfishing. Illegal, Unregulated and Unreported (IUU) fishing is widespread in Myanmar. It is almost impossible to effectively manage for sustainable use of marine resources if laws are not adhered to and managing bodies do not know the full extent of extraction.

Destructive fishing

Fishers are using inappropriate technologies in certain areas and this can lead to destructive fishing. For example, trawlers are ignoring laws forbidding targeting inshore waters and they destroy delicate and important nearshore habitats such as reefs and seagrasses. They also tend not to use appropriate technology. TEDs on trawling equipment can allow marine turtles to escape, but anecdotal evidence suggests that most trawl fishers have not yet incorporated them into their nets.

Undisciplined Tourism

Despite the MoHT's efforts to develop and disseminate guidelines for coastal tourism development, there have been few strong regulations governing sustainable growth of the sector along coastal areas. Poorly planned tourism developments can lead to destruction of near-shore habitats through construction, dredging, sedimentation and pollution; social issues through livelihood displacement and inequitable distribution of resources; and overfishing.

Well-planned tourism growth that considers the various social, economic and environmental impacts and incorporates thoughtful planning, outreach and mitigation efforts could have net positive benefits on long-term human and environmental health. With the anticipated growth of tourism, MoHT is considering environmental sustainability and marine issues can be incorporated into planning. The MoHT's recent development of policies relating to responsible tourism and community involvement in tourism reflect a commitment to consider these issues within the sector's development.

Watershed Degradation

Watersheds can be degraded through poorly regulated and planned coastal and riverside activities. Agricultural runoff and sedimentation can choke and poison marine habitats, plants and animals. Myanmar's scientists and government staff have cited this as a major threat that needs attention and legislation.

Extractive Industries

In addition to the direct harvest of marine life through fisheries, other extractive industries may negatively affect the marine environment.

Altogether there are 101 blocks set aside for oil and gas exploration in Myanmar including 48 offshore blocks. As of January 2012, there were 12 foreign oil companies working in 27 offshore blocks: 10 off the Rakhine Coast, 12 near the Gulf of Mottama and 5 off the Taninthayi Coast (Kyaw Tint *et al.*, 2012b) (Figure 2). Offshore oil and gas extraction carries a series of potential threats and spills can be catastrophic to marine life. The primary environmental risk stems from the possibility of oil spills from oil tankers or pipelines transporting oil and from leaks and accidents during the drilling process.

Oil spills can affect a range of marine life in the short and long term. Through coating hair and feathers, oil destroys the insulating abilities of mammals' fur and the water-repelling quality of bird's feathers. These animals can also be poisoned through ingesting oil. Oil in the water column can also be consumed by shellfish and finfish. It has been found that finfishes exposed to oil may experience reduced growth, enlarged livers, changes in heart and respiration rates, fin erosion and reproduction impairment (National Oceanic and Atmospheric Administration, Web page). Oil on the water's surface limits light penetration below, affecting marine plants and phytoplankton. Oil can wash ashore and impact coastal communities through killing algae, other plants and a wide range of animals. Certain compounds from oil, namely the cyclic hydrocarbons such as benzene, toluene and xylene, are soluble in water and can reach marine life that didn't have direct contact with the oil. A well-studied spill in Panama documented the widespread and devastating impact of the spill on mangroves, seagrasses, algae, invertebrates and coral reefs (Jackson *et al.*, 1989).

Water is often used in the oil extraction process offshore and, in offshore operations, it is released directly into the sea. This "produced water" contains varying amounts of oil and other compounds and is another source of oil pollution in addition to those from leaks and accidents.

Industrial and infrastructure development relating to the growth of extractive industries also threaten coastal areas. Currently, three major coastal centres are being considered for large-scale industrial development: Dawei in the Taninthayi, Thilawa Port near Yangon, and Kyaukphyu in the Rakhine. Kyaukphyu could be the most impactful since plans include huge infrastructure supporting offshore oil drilling, pipelines, oil refineries, and a deep-sea port.

Myanmar has a long history of mining gemstones and gold and large mineral potential still exists. The Ministry of Mines is working to attract foreign investors and boost production to fulfill domestic needs and export potential. Poor industry standards and operations could result in discharge of noxious elements into fresh water and marine systems including mine tailings or poisonous chemicals such as arsenic and cyanide that are used by some extraction procedures. Offshore mining for minerals is a burgeoning industry that may also be considered in Myanmar. It is currently being developed in Papua New Guinea and its range of impacts is still unknown.

Another extractive industry of concern is sand mining. Currently sand is being mined from river bottoms and the sandy sea floor within the Myeik Archipelago for export to Singapore for use in construction and land-reclamation. It is unclear the extent of impact these operations may have on deep water and nearshore ecosystems. Other countries in the region, including Indonesia and Malaysia, have enacted bans on the industry because of environmental concerns.

Research Gaps

Research is a critical component to improving the understanding of the current state of Myanmar's marine resources, identifying the primary

© Aung Aung Aye

Big boats trawling in inshore areas often can damage shallow marine habitats such as seagrass beds.

threats to the sustainability of those resources and creating realistic plans for effective conservation and management. Stakeholders highlighted that there is insufficient funding and field and laboratory equipment available to support excellent research. Currently there is weak in-country capacity to conduct research. Poor communication channels and difficult logistical planning can be time consuming. Policy makers do not have sufficient data from which to develop action plans.

Inadequate Policies and Laws

The various laws regulating fisheries make concerted efforts to protect various marine systems and species. However, without adequate compliance and enforcement, many of these laws are ineffectual. There is a lack of funding for law enforcement and few incentives for compliance.

There is a lack of clarity on some laws and legal structures. It is not clear to many stakeholders at to who, between national and State/Regional governments, has authority over fishing concessions. There is confusion among government officials as to how to interpret the delineation of inshore and offshore zones. It is not clearly stated in the fisheries laws whether the coastline from which the inshore fishing zone is defined includes the coasts of islands or only the main land.

Related to this, some of the country's States and Regions lack a clear set of policies on resource management and development plans.

Climate Change

Climate change is expected to exacerbate existing threats to Myanmar's biodiversity both directly through habitat loss and reduced resilience of ecosystems and indirectly through impacting people and their dependence on natural resources. Rao *et al.* (2013) provide a summary of anticipated impacts and vulnerability ratings for ecosystems from extreme weather events throughout Myanmar.

In terms of marine coastal systems, communities living on the shore and on islands are particularly vulnerable to climate change. Sea level rise, salt-water inundation and increasing frequency and strength of storms can lead to failed crops and human displacement. Meanwhile, increasing water temperature and ocean acidification will affect nearshore reef ecosystems in both predictable and unpredictable ways, negatively impacting the food security of coastal peoples. Increased water temperatures paired with sea level rise will accelerate coastal erosion and impact estuarine communities, mangroves and reefs and displace coastal communities. Cyclone Nargis of 2008, the worst natural disaster in the country's recorded history, killed over 146,000 people and affected over 7 million people, many through damaging the coastal ecosystems on which they rely. Habitat destruction, namely the clearance of mangroves for rice paddies and charcoal production, exacerbated the destructive impacts of the cyclone. In the area of the Ayeyawady Delta that was worst hit, little primary growth mangroves were found within 30 km of the coast (Fritz *et al.*, 2011).

The Myanmar Action Plan for Disaster Risk Reduction (MAPDRR) of 2012 explicitly discusses the unique vulnerabilities of coastal communities and has given high priority to the production of cyclone and storm surge vulnerability maps for coastal areas. This effort is to be lead by the Department of Meteorology and Hydrology, the Settlement and Land Records Department and Local Governments; to be contributed to by the Irrigation Department and the Department of Health; and to be partnered by the Myanmar Information Management Unit, the Myanmar Engineering Society, the Myanmar Geosciences Society, UN Agencies and International NGOs.

Community Issues

Many coastal communities of Myanmar are poor and sometimes isolated, affecting their interaction with natural resources. People who have low education levels and possibly little contact with outsiders may have low levels of awareness. Without access to alternative livelihoods, they may rely solely on fishing and gleaning for subsistence and entry into the cash economy. These factors and immediate needs can influence their ability to consider the long-term sustainability of resources on which they depend. Furthermore, poor communities are less resilient to the impacts of climate change due to limited resources for adaptation.

Weak Collaborations

Workshop participants highlighted that collaboration and coordination among people working toward the continued health of marine resources is often weak. There are no formalized mechanisms or incentives that encourage collaboration and communication between the various stakeholders.

© Katherine Holmes/WCS

RECOMMENDATIONS

NATIONAL MARINE SPATIAL PLAN

Myanmar's marine resources are being accessed and impacted by a wide range of stakeholders with growing influences. Tourism is increasing and large-scale tourism developments are anticipated in the Tanintharyi area. In March 2014, the government of Myanmar awarded 20 new offshore oil and gas blocks to foreign firms for exploration and development, doubling the area of offshore habitat given up to oil and gas production. Foreign fishing vessels in Myanmar may decline due to the 2014 parliamentary ban of foreign fishing boats. And, since the 2013 lifting of economic sanctions, already poorly-understood fishery export markets entered a period of flux and new markets for nearshore marine resources may emerge, which will influence fishers' livelihoods.
A national-level spatial planning exercise will allow for a clearer understanding of the influences and interactions of these and other marine-related activities across Myanmar's EEZ. A national level management plan can be developed based on a strong understanding of the distribution of the range of marine influences in Myanmar's waters. Therefore, we recommend the following:

- Develop a national marine spatial plan for conservation and development, including marine protected areas, community-based coastal management areas, industrial development areas, allotments for tourism development, and fishery zones.

This effort would require the following components:

- Data collection from academic partners, government bodies, and NGOs to build a national marine spatial plan.
- Gap assessment of additional data needs across the entirety of Myanmar's EEZ.
- Data overlay and analysis using marine spatial planning tools to provide a foundation for an interactive process that considers the range of competing priorities and allows for the involvement of a range of users.
- Stakeholder review/consultation process.
- Draft marine spatial management strategy that will include a proposal for the expansion of habitat and biodiversity protection for both fisheries production and precautionary preservation through a representative network of marine protected areas.

Such an exercise would have a range of outcomes:

- Inform tradeoff decision-making processes concerning development and conservation allowing for improved government planning for sustainable use and conservation of Myanmar's marine environment.
- Increase multi-sector collaboration for sustainable and equitable use and conservation of Myanmar's marine environment.
- Improve the sustainability of artisanal and commercial fisheries.
- Develop policies and interventions to increase protections for specific threatened marine species.

SUSTAINABLE FISHERIES CONSERVATION STRATEGY

Fisheries provide the dominant livelihoods in many of Myanmar's coastal regions, the extent and sustainability of which is unknown. In March 2014 a Norwegian government-funded survey of pelagic and demersal fish stocks across the entirety of Myanmar's Exclusive Economic Zone revealed that pelagic fish stocks currently stand at 10% of their 1979 biomass, with similar estimates for coastal fisheries. Endangered sharks and rays are also increasingly being landed for sale to foreign markets. According to the FAO, Myanmar's fisheries sector provides close to 1 million jobs for coastal fishers directly and nearly 3 million jobs indirectly. A sustainable fisheries conservation strategy would aim to reverse the current trajectory of marine resource decline in the country. We recommend the following:

- Develop a sustainable fisheries conservation strategy, to link the lessons of a growing range of ground-level field projects to national level top down support for fisheries research and reform. The plan would engage with commercial and artisanal fisheries as well as seek species protections for marine taxa such as sharks and rays.

This strategy would need to include both ends of the fisheries spectrum, from industrialized offshore fleets to bottom up community-based coastal fisheries management, ubiquitous in much of the developing world. The holistic strategy should include the following three components:

- Offshore fishery assessment and conservation strategy. Potential solutions for industrial fleets may include top-down controls such as Vessel Monitoring Systems, increased fishery observer programs, stock modeling, or even quota or spatially-based property rights.
- Inshore fishery assessment and conservation strategy. A critical component to successful small-scale fisheries management will be the

introduction of a legal framework that allows for co-management by coastal fishers and their communities.
- Species protection strategy. This could focus on some of the species groups, outlined below.

A sustainable fisheries strategy would have numerous impacts, including the following:

- Improve the sustainability of artisanal and commercial fisheries.
- Positively impact local livelihoods in the coastal regions.
- Allow for coordinated action on a national level for particularly vulnerable animals such as sharks and rays.

COMMUNITY-BASED COASTAL MANAGEMENT

Community-based coastal management involving clear, integrated management plans can be used to conserve a range of coastal habitats and the species and people that rely on them.

Before additional coastal conservation activities are started, it would be useful to understand what has worked and what has not in the current system and to establish what actions are needed to clarify and achieve realistic goals. This analysis could then be placed in the wider context of lessons learned to date involving community-based natural resource management in Myanmar and the potential application of such to coastal conservation. The analysis could include the following:

- Conduct a lessons-learned analysis of Lampi Marine National Park, identifying legal structures, history of the process, current protective measures, threats and challenges, to assess the functioning of the park.
- Conduct a similar analysis of other nearshore conservation areas including Meinmahla Kyun, Thamihla Kyun and Moscos Island Wildlife Sanctuaries, as well as the conservation areas for lobsters and clams in Thanbyuzayat and Pulaw Townships respectively.
- Analyse community natural resources management approaches used to date in fisheries and forestry by DoF, FD and NGOs, and their potential application in coastal ecosystems.
- Conduct an assessment of co-managed fisheries such as that in Bogale Township, where village fisheries sectors were allowed to manage some aspects of local fisheries. Analyses should, in particular, consider the legal structure of co-management.

Community-Based Natural Resource Management (CBNRM) and co-management approaches could be used to establish a community-based coastal conservation initiative. This is in line with the suggested action of the National Biodiversity Strategy and Action Plan (2011) to "develop participatory approaches for community based fishery resource conservation and management" as one of its stated objectives within its "Five-year Action Plan Toward Sustainable Management of Coastal, Marine and Island Ecosystems". On-the-ground conservation efforts could tie into larger efforts being conducted at national and even regional levels such as in a multi-scale project addressing the conservation of a target species and testing co-management approaches. Such efforts would involve working with a subset of vulnerable island communities and could involve a series of activities:

- Conduct a Village Consultation Process (VCP) in communities to identify natural resource use, priority species and habitats and threats.
- Use participatory mapping to assess resource use.
- Develop a local biological monitoring approach, modeled after similar monitoring approaches used elsewhere (such as in Locally Managed Marine Areas in the Pacific).
- Conduct socio-economic monitoring to understand the current state of reliance on marine resources and to measure changes over time.
- Evaluate susceptibility to the effects of climate change.
- Assess the roles of community organisations to understand how they shape and impact decision making.
- Test community co-management approaches through developing Community Management Plans. These may incorporate protection measures (such as quotas, size restrictions or gear restrictions), remediation measures (such as replanting mangroves), or spatial management (such as no-take areas).

A suggested geographic focus for this work would be in a subset of islands of the Myeik Archipelago. There are a number of reasons for this focus:

- Trends in tourism suggest that this area will likely experience greater near-term changes in pressures on the resources and a shifting composition of stakeholders. It is likely that increased tourism in the region will lead to more opportunities for livelihood diversifications but, if poorly planned, also resource depletion. This will be a critical time to work with communities to understand and benefit from these changes.

- The Taninthayi Coast supports the more diverse and rich marine communities in the country. These communities are under-studied and, while there are indications the area is already suffering from over-exploitation, there is no understanding on the degree to which these systems are already being degraded.
- Through working with a small subset of island communities, managers would learn the nature of the issues facing these communities and effective ways to engage with them. In time, community engagement projects could take lessons learned and expand to other communities in the region, thus creating a network of areas and increasing the impact of the efforts.

MARINE MEGAFAUNA PROTECTED AREAS

A number of Myanmar's priority species are threatened by the use of nets and longlines. These include sharks, rays, five species of marine turtles, cetaceans and dugongs. We propose the creation of a coordinated, multi-taxa initiative to create zones that aim to benefit multiple species through gear restrictions by location and or season. Such an initiative would involve the following:

- Evaluate and improve the implementation of the existing Shark PAs (see below), which would be a critical first step. Lessons learned can inform the creation of future marine PAs
- Conduct a spatial risk analysis based on deployment points of fishing gears, species distributions, and seasonality and habitat models.
- Use these maps and analyses to identify
    - Key areas of overlap between species of conservation concern with areas heavily used by fisheries. These are areas where the probability of entanglement with fishing nets would be high.
    - Areas of high fishing use but lower levels of species occurrence. These are areas where fishing with standard fishing gears could be continued.
- Consult with stakeholders to choose a subset of areas for protection through gear restrictions.
- Integrate megafauna-friendly actions with other conservation efforts such as the DoF's National Plan of Action (NPOA) for sharks and research activities relating to marine turtles.

LEGAL REFORM AND IMPLEMENTATION

Myanmar's coastal communities are not legally empowered to contribute to decision-making relating to the management of the marine resources they rely on. Current legal structures and enforcement capabilities are not sufficient to support the enforcement of fisheries regulations and compliance to laws is low. Stakeholders emphasized the need to improve enforcement and compliance through clarifying and reforming laws and enforcement. Recommendations relating to legal reform and implementation include:

- Based on assessments of natural resource management approaches and in consultation with the DoF and other stakeholders, suggested provisions for fisheries co-management should be developed. This would allow for improved community participation in fisheries management, which could lead to better compliance and more effective management.
- Relevant laws could be updated through reviewing the policy and existing laws with research and public participation.

Mechanisms to clarify and communicate relevant laws and notifications across stakeholders are needed, such as the definition of coast within the "Myanma Marine Fisheries Law".

In cases where compliance is low and resources are insufficient for adequate enforcement, consideration should also be made for other ways to improve compliance. For example, where laws are in line with local beliefs and attitudes, it may be possible to improve compliance through education and outreach. A no-fishing zone was established by monks of the Namada Pagoda and Monastery along a section of the Ma Yu River and, although not legally recognized, it is well respected by local fishermen.

ECOSYSTEM-SPECIFIC RECOMMENDATIONS

Coral Reefs

The coral reefs of the Myeik Archipelago are poorly studied due to the unique requirements for researching these distant and deep systems, namely high costs (for fuel and specialized equipment) and unique skills (such as SCUBA diving). However these systems are being exploited by SCUBA divers and fishers for recreation and extraction purposes. Long-term observations by recreational divers suggest that exploitation on remote reefs has increased

dramatically in recent years. Recommendations are, therefore, broad and large in scale:

- Support local research and collaborations to develop local capacity to study and monitor coral reefs.
- Design a monitoring protocol appropriate to local capacity and resources that will be able to
  - Identify the 'baseline' state of reef systems and
  - Reveal predominant and site-specific threats.
- Work with local communities on management plans that incorporate mitigating threats to coral reefs along with other issues (climate change, overfishing, sustainability, livelihoods), ecosystems and organisms (target food fish, sharks, marine turtles).
- Blast fishing must be reduced immediately through awareness raising activities, legislation and enforcement.
- Tourist shops, curios sellers and tourists should be made aware that transporting coral products from Myanmar and into many other countries is illegal under CITES.

Seagrass

Trawlers operating in the inshore areas can destroy nearshore habitats such as seagrass beds. The current impact level from this fishing activity on Myanmar's seagrass beds is not known. Seagrasses in Myanmar are likely to face a range of new threats during the anticipated increase in development.

- Bans on "baby trawlers" in nearshore areas need to be enforced.
- The importance of seagrass beds needs to be emphasized at all national and regional meetings relating to coastal zone planning so that decision makers remain aware of the need to protect this habitat.
- Seagrasses need to be considered in future EIAs so as to minimize negative impacts on their health during inevitable coastal development projects.
- The MoHT needs to be aware of the importance of coastal habitats to marine life and the burgeoning coastal tourism sector that depends upon it. Tourism developments occurring in coastal areas should be legislated to minimize the removal of seagrasses (as well as mangrove and reefs) during their coastal development activities.
- University marine science departments should encourage further research on the distribution of seagrasses and the identification of particularly healthy stands or those important to science that might warrant targeted, spatial protection. These may include stands dominated by *Cymodocea serrulata* in the Rakhine Marine Corridor and *C. rotundata* in the Taninthayi Marine Corridor.

Mangroves

Due to the dramatic levels of threats and encroachment along with the wide recognition of the services that mangroves play in shoreline protection, particularly after Cyclone Nargis, mangrove systems have received substantial attention from government departments and NGOs. The FD has collaborated on projects using an Integrated Management Approach that combines environmental management with economic development. Unfortunately the scale of impact of this work pales when compared to the estimates of habitat already affected. This study therefore makes the following broad recommendations:

- The FD's Integrated Management Approach should be replicated and expanded.
- Where mangroves still form contiguous cover, there may be enough potential for natural regeneration and recovery, but this would require protection from further encroachment and fragmentation.
- In other areas, replanting methods would need to be used to encourage any recovery as part of a management plan. Reforestation could be done with local mangrove species such as *Avicennia officinalis* and *Sonneratia apetala*.
- Efforts to help communities manage firewood and timber extraction from mangroves at sustainable levels, especially in the Ayeyawady Delta region should be expanded.
- Conversion of mangrove to shrimp ponds and rice paddies in the same areas must be curtailed dramatically.
- A broad Mangrove Management Plan should be developed for the entire tracts of mangroves in the country. The soon-to-be created Mangrove Conservation Division under the FD will, ideally, evaluate the critical ecosystem services provided by the habitat in various areas and include zoning. The Division should:
    - Evaluate mangrove contribution to fisheries.
    - Identify potential acid-sulphate soil problems relating to shrimp ponds.
    - Assess economic and social values of the mangrove stands.
    - Assess likely role of mangroves in protection of human populations and agriculture from storm surges.
    - Evaluate the potential for aquasilviculture with shrimp farming to diversify income risk.
    - Study sediment dynamics to understand the role of mangroves in sediment entrapment deposition and erosion to identify particular areas where mangroves are providing critical protection.

SPECIES-SPECIFIC RECOMMENDATIONS

Sharks and Rays

The creation of a national multi-stakeholder Shark and Ray Advisory Committee, involving the DoF, the Navy and conservation NGOs, could guide the Shark NPOA as well as any other conservation, management or legislative processes involving elasmobranchs. This committee could oversee necessary steps toward developing the NPOA, which would include the following:

- Review of the current laws relating to shark captures and legal structures for enforcing Shark PAs.
- Review of enforcement activities and protocols through interviews with those authorities involved.
- Assessments of the level of exploitation through market surveys similar to those conducted in 2004.
- Workshops with Navy and DoF personnel to assess the threats, challenges and possible solutions relating to management of Shark Protected Areas.
- Assessing the level of fisher displacement and/or socio-economic impacts and alternatives from the creation of the Shark Protected Areas.
- Visiting sites with Navy collaborators to assess operational threats to shark reserve effectiveness.
- Interviewing local communities to assess their perceptions and understandings of shark fishing pressure within the current protected areas and identification of culturally and economically viable livelihood alternatives.
- Identifying public perception of sharks and rays and using preliminary results to develop an outreach and awareness campaign for Myanmar.
- Providing recommendations to key enforcement agencies and personnel to improve law enforcement effectiveness.

Sharks are a priority species for dive tourists who are attracted to the relatively isolated waters of Myanmar. Efforts to halt the illegal harvest of sharks can be tied with initiatives to develop a sustainable tourism industry. Activities relating to shark conservation and tourism could include:

- Conducting consultative workshops and planning with the MoHT with respect to dive tourists.
- Assessing the impacts and distribution of benefits from tourism initiatives related to sharks.
- Developing educational and awareness campaigns on the importance of sharks that are tied to larger, income-generating initiatives such as tourism.
- Exploring novel income-generating approaches for conservation and awareness projects benefiting first and foremost communities utilizing resources in the shark reserves.

Additional understanding of shark and ray populations, distributions, seasonality, critical habitats and behaviour would inform and underpin management actions. Approaches similar to those used in other locations in the world could be replicated in Myanmar. WCS has initiated a research program in Belize that has been successful in standardizing baseline assessments for sharks that is now being extended to neighbouring countries. Research activities could involve:

- Collaborative research between the DoF and international NGOs or researchers with experience in shark research
- A bottom up approach that is standardized and scalable to other sites in Myanmar and ultimately the SE Asian region so that the status of sharks and rays in different sites and countries could be compared
- Peer to peer exchanges between countries that could be implemented for participants in the different sectors (fishing, tourism, enforcement, science) to promote an exchange of lessons learned and prepare for CITES enforcement requirements

Considering the uplisting to Appendix II of five of Myanmar's shark species and two of its ray species at CITES COP 16 in 2013, Myanmar needs to prepare for implementing controls needed for trade in sharks. Recommendations include:

- Conduct a review of the monitoring, documentation, and controls needed for trade in sharks and rays.
- Assess the current procedures and needed procedures for CITES processing in Myanmar, including permitting procedures, port procedures and licensing procedures.
- Identify training and materials needed to support implementation.

Marine Turtles

- Continue and strengthen the enforcement of protection laws (no mechanized near-shore fishing, no harvesting of eggs, release of turtles caught in fishing gear).
- Introduce a programme and legislation to further encourage the use of TEDs with trawling gear.
- Conduct a Myanmar-wide mapping exercise using consultations with local experts and field interviews to inform designation and management of Marine Megafauna Protected Area(s).
- Improve hatching techniques following the specific recommendations outlined by the IOSEA advisor.
- Extend "wildlife sanctuary" protection status to existing nesting beaches.

Crocodiles

- Conduct rapid surveys along Rakhine and Taninthayi's coastlines to check where crocodile populations remain.
- Establish a monitoring programme at Meinmahla Kyun Wildlife Sanctuary for the large, robust and possibly increasing crocodile population.

Cetaceans

- Assess near and inshore shore cetacean populations more rigorously with special emphasis on identifying preferred habitat for focal conservation attention.
- Incorporate cetaceans into initiatives to establish a network of conservation areas along the Taninthayi and Rakhine Coasts where gill netting would be eliminated or dramatically reduced. This could be independent or as part of a larger Marine Megafauna Protected Area, as proposed above. Priority areas already identified for cetacean protection include:
  - Rakhine:
    - Lower reaches of the Meybone River and adjacent coastal inlet to the south,
    - Ma Yu River, upstream of the one already established by the Namada Pagoda and Monastery
  - Taninthayi:
    - The Salon-Daung channel between the east side of Sakhan Thit Island and the

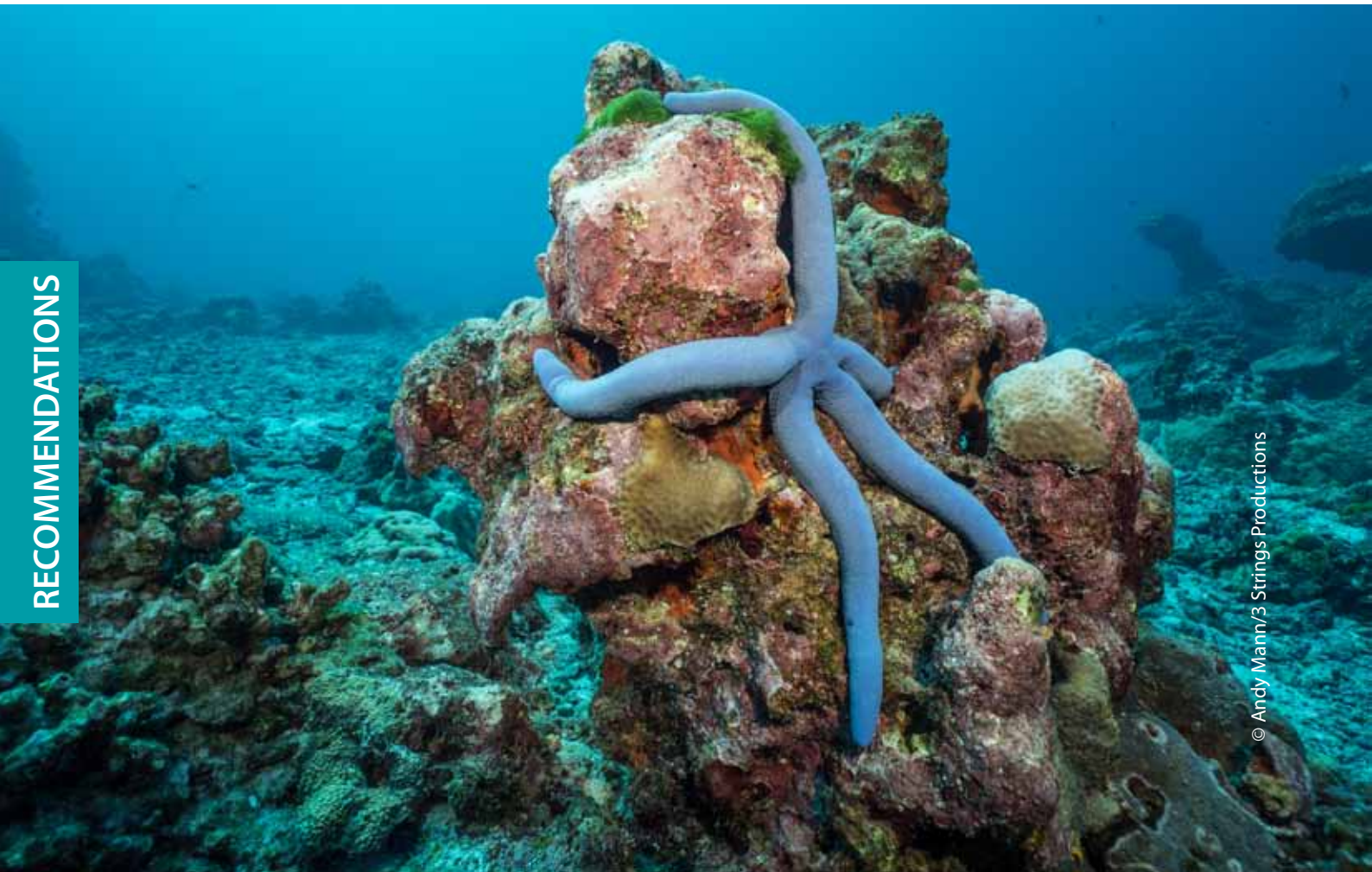
mainland
    - The south of the Kau Yea Straights in the channel between Sit The Kyunn Gyi Island and the mainland.
- Investigate incidental and intentional catches and identify ways to reduce or eliminate them especially in inshore and nearshore waters inhabited by threatened species (e.g., Irrawaddy dolphins and Finless porpoises).
- Educate about and enforce laws that prohibit the intentional killing of cetaceans and the sale of products, including meat, oil and bones, from marine mammals.
- Assess the potential for integrating well-managed dolphin and whale watching tourism into marine mammal research and conservation efforts.
- Conduct an inventory of whale skeletons in the country including confirming and updating descriptions, identifications and location data.
- Incorporate messages on cetacean conservation and use them as flagship species for marine conservation in educational outreach and education initiatives.

Dugongs

- Conduct a threat assessment of seagrass areas that have been identified as priority habitat for dugongs and identify ways to protect these areas from loss and degradation.
- Initiate integrated management campaigns for conservation management in these areas that include:
    - Conducting aerial surveys of dugong populations and seagrass beds in areas identified as hotspots for dugongs particularly along the Rakhine Coast.
    - Assessing the feasibility of creating conservation areas in sea grass beds where gill nets and bottom trawling are prohibited. Note that this work could be done in conjunction with baseline research needed to establish Marine Megafauna Protected Area(s), as proposed above.
    - Building on awareness campaigns already conducted by the DoF and involve local NGOs, such as the Rakhine Coastal Region Conservation Association, to foster a sense of pride and stewardship over fragile dugong populations.

Squids

- Continue to monitor catches of squid at major landing sites.
- Work with international bodies to improve monitoring and studies with the aim of generat-



ing accurate stock assessments.
- Consider and review management and regulatory actions to assure sustainability of the fishery.

Prawns and Shrimps – Live Capture

Official data show wild caught marine shrimp capture increased more than three fold in the decade up to 2011 however other studies have found that landings peaked in 2001 in Myeik. Extreme levels of exploitation and decreased landings in some areas suggest that wild caught stocks may be falling below their carrying capacity.

- Stock analyses should be performed on the most up to date set of fisheries data to determine the status of wild prawn and shrimp stocks. DoF should use findings from this to make informed management decisions on potential restrictions.
- Legislation which forbids the use of trawl nets in inshore waters needs to be enforced to protect delicate and important nearshore habitats.

Prawns and Shrimps – Farming

Government officials from both FD and DoF are well-aware of the issues around prawn farming and mangrove deforestation in the country and, there is concern and institutional desire to see that protection measures to date continue to be strengthened. Various considerations should be made to effectively manage any expansion of this aquaculture practice in Myanmar:

- Efforts should be made to upgrade and rehabilitate low productivity coastal ponds and degraded mangrove systems through removing acid and toxic leachates or implementing aquasilviculture rather than cutting healthy mangroves.
- A national-level Mangrove Management Plan, described above, should include consideration of the impacts of prawn and shrimp farming.
- A comprehensive environmental management plan should be developed in coordination between the DoF and private sector shrimp industry in Myanmar and could create a voluntary Code of Conduct to guide development of the industry.

Spiny Lobsters

- The DoF should create notifications that dictate size limitations for capture and sale of species within the genus *Panulirus*. This should involve consultation with exporters who also value larger lobsters and would be key in implementing the restriction.
- As there are five different species in the fishery, the life histories, in particular, the size at sexual maturity, of each species should be evaluated in order to decide if more than one size limitation would be needed and what the size(s) should be.
- Gravid (with eggs) lobsters should be restricted for sale (similar to Notification No. 3/95 that protects gravid prawns).
- The fishery's stocks would benefit from restricting gear use to selective methods (such as traps rather than gill nets) to help the stocks recover and to create a sustainable fishery.
- Awareness programmes may help fishers understand the importance of any introduced restrictions protecting juvenile and berried lobsters.

Crabs

- Additional research on mud crabs (*Scylla serrata*) is needed to determine the sustainability of present harvest and farming practices to generate advice on sustainable management.
- Research on Frog crabs (*Ranina rania*) populations of the Taninthayi Region would benefit management decisions relating to this relatively new fishery.

Seaweeds

- Legislation of seaweed farming needs to be introduced before there is any further expansion of the industry. Legislation should include:
  - Regulations around species and nursery stock to prevent the import of potentially invasive species
  - Prohibitions on removing mangroves for seaweed culture
  - Limits on the area of seagrass beds to be directly impacted by any open-sea seaweed culture operation

Shellfish

The impact of shell collecting for the curious trade needs to be assessed including identifying source populations and assessing the sustainability and carrying capacity of the populations.

Sea and Coastal Birds

- Additional surveys of bird populations are needed at a range of Myanmar's coastal and marine habitats to improve our understanding of these poorly known species and their dynamic ecology. Habitats include pelagic waters, the Cocos Islands, mud flat areas used by wintering shorebirds, undisturbed mangroves tracts and offshore islands.
- Survey work should be used to inform Myanmar's government of areas of high conservation importance and identify management opportunities to conserve these areas. This could include the expansion of the National Protected Areas network as well as smaller community-managed conservation schemes for specific species or important nesting or wintering areas.
- With a projected dramatic increase in tourism, community-based enterprises could be linked with nature tourism.

RESEARCH

Myanmar's University Zoology and Marine Science departments are eager to improve the capacity of their institutions and students, expand their impact on the understanding of Myanmar's marine resources and increase collaboration with outside researchers. Recommendations relating to these needs, include:

- Establish a "Marine and Coastal Resources Research Centre" administered through the DoF and Mawlamyine University's Marine Science Department, in conjunction with Myeik University where it could be based, with the following functions and responsibilities:
    - To provide a formalized structure for collaboration and coordination between DoF and the Ministry of Education for research and conservation activities
    - To engage and coordinate marine scientists from across Myanmar's universities and the DoF
    - To provide a mechanism for foreign researchers to collaborate with students and academics
    - To provide a mechanism for NGOs conducting conservation research to access and support students interested in the marine conservation field
    - To provide training to students in essential field skills such as snorkeling and SCUBA diving
    - To facilitate information sharing through hosting workshops and serving as a repository for research reports, papers and materials relating to marine research and conservation
- Improve Local capacity in particular areas of research including skills needed for publishing in peer-reviewed journals through collaborative research.
- Address gaps in marine research as identified by Myanmar's academics, namely:
    - Identify indicator species for environmental and ecological studies.
    - Generate data needed for policy makers and action plans.
    - Develop long-term ecological studies on specific species.
    - Develop monitoring programmes of water quality.
- Students could further and better explore the taxonomy, population structures and dynamics of Myanmar's marine life through access to high tech facilities in international laboratories. For example, international universities can provide training and facilities for genetic analyses, GIS skills and computer modeling.

CLIMATE CHANGE

Community-based planning activities by NGOs and other organisations can help improve local adaptive capacity for the most vulnerable popula- tions through a range of activities:

- Conduct awareness-raising activities for local communities around climate change.
- Incorporate planning for the impacts of climate change during co-management activities such as the creation of Community Management Plans.
- Expand and link conservation areas and the pro- tected area network to help maintain a diverse set of intact marine habitats and viable popula- tions of marine species.
- Support activities planned within the MAP-DRR.
- Contribute to advanced climate modeling stud- ies to understand changes in climate on spatial and temporal scales to influence planning.

TOURISM

The state of the Taninthayi Coast's marine system has already started to decline in terms of its value for dive-based tourism. Through efforts to limit domestic waste, blast fishing and the abandonment of fishing gear, some aspects of Myanmar's special qualities for tourism (such as a sense of remoteness and isolation) might be maintained. Improvements in these areas will also help maintain healthy marine resources for the needs of other stakeholders beyond those benefitting directly from tourism.

- Tourism development plans should take into account the importance of healthy marine habitats, healthy fish and shark populations and a clean environment for marine-based tourism.

- University marine science departments, the DoF and NGOs focusing on environmental conservation could contribute to tourism development plans.

- MoHT directives for the private sector, which currently include guidelines for building and operations, should be improved to specifically include measures and restrictions intended to limit harmful impacts from marine tourism on the marine environment. These could include items such as regulations on how hotels are to process sewage and detailed limitations on the direct alteration of marine habitats during construction.

- Tourism initiatives from other countries should be looked to for models on best practices and innovative income generating approaches. For example, portions of income generated through tourist fees could be directed toward targeted marine conservation efforts.

© Katherine Holmes/WCS

REFERENCES

Abbott, R.T. 1991. Seashells of Southeast Asia, American Malacologists. 204 pp.

Abbott, R.T. and S.P. Dance. 2000. Compendium of Seashells. A Full-color Guide to more than 4,200 of the World's Marine Shells. Odyssey Publishing, El Cajon, US. 411 pp.

Ahmad, A. and A.P.K. Lim. 2012. Field Guide to Sharks of the Southeast Asian Region. SEAFDEC/MFRDMD. 210 pp.

Ahmed, N., A. Occhipinti-Ambrogi, and J.F. Muir. 2013. The impact of climate change on prawn postlarvae fishing in coastal Bangladesh: Socio-economic and ecological perspectives. Marine Policy 39:224-233.

AlgaeBase. Web page. http://www.algaebase.org/

Anderson, J. 1878. Anatomical and zZological Researches: Comprising an Account of Zoological Results of the Two Expeditions to Western Yunnan in 1868 and 1875; And a Monograph of the Two Cetacean Genera, *Platanista* and *Orcaella*. 985 pp.

Angell, C., L. 2004. Review of Critical Habitats: Mangroves and Coral Reefs. Report, Bay of Bengal Large Marine Ecosystem Project. 87 pp.

Associated Press. 2014. 'Paper parks': Myanmar habitats where official protection is not worth the paper its written on. http://www.scmp.com/news/asia/article/1465869/paper-parks-myanmar-habitats-where-official-protection-not-worth-paper-its

Aung Aung Aye. 2010. Review on the species composition of croaker fish commonly found in Myeik Waters. Master of Science. Myeik University.

Aung Hlaing Win and Maung Maung Lwin. 2011. Interaction between fishing activities and marine turtles in Myanmar. *In* Proceedings of the 7th International Symposium on SEASTAR2000 and Asian Bio-logging Science (The 11th SEASTAR2000 Workshop), March 8-9, 2011. Bangkok, Thailand. 5-7.

Aung Moe, B.K. 1993. Conservation, management and farming of crocodiles in the Union of Myanmar. *In* 2nd Regional (Eastern Asia, Oceania, Australasia) Meeting of the IUCN-SSC Crocodile Specialist Group. IUCN. 9-11.

Aung Myint. 1980. The culture of *Catenella nipae* Zanardini (1872) under laboratory conditions. Moulmein College.

Aung Myo Chit, B.D. Smith, and Mya Than Tun. 2012. An extreme extra-limital record of a strap-toothed beaked whale *Mesoplodon layardii* from the northern Indian Ocean in Myanmar. Marine Biodiversity Records 5:1-3.

Aung Myo Htay. 2005. Studies on the management strategies of local shrimp farming in Ma-Gyi area, Ayeyarwady Division. Master of Research. Pathein University.

Aung Phyo Oo. 2012. Study on the hard corals (Cnidaria: Hydrozoa and Scleractinia) collected from Kanpani coastal areas. Master of Science. Mawlamyine University.

Aye Aye Cho. 1987. The anatomy and histology of *Ompok pabo* (Hamilton, 1822). Arts and Science University, Rangoon.

Aye Aye Khine. 2000. Taxonomic study of some decapods from Sittway Township, Rakhine State. Master of Science. University of Yangon.

Aye Aye Maw. 1994. The anatomy and histology of *Pseudorhombus arsius*, Gunther. University of Yangon.

Aye Aye Min. 2011. Impacts of shrimp farming in mangrove area of Pyindaye reserved forest in Pyapon District, Ayeyarwady Region. Doctor of Philosophy. University of Yangon.

Aye Aye Mon. 2006. Seasonal occurrence of prawn and shrimp species from Taunggalay Village (Ngaputaw Township: Ayeyarwady Division). Master of Research. Pathein University.

Aye Aye Mon. 2012. Study on the mangrove community of Kadut Creek, Lamaing Township, Mon State. Master of Science. University of Mawlamyine.

Aye Nyein Thu. 2010. Occurrence and processing of live spiny lobsters for marketing at Chaungtha, Pathein Township, Ayeyarwady Division. Master of Research. Pathein University.

Aye Thida. 2003. Growth estimation of juvenile seabass *Lates calcarifer* (Bloch, 1790) based on scale microstructure. Master of Research. University of Yangon.

Aye Thida Thein. 1982. The taxonomic studies on the Burmese marine nerites (Gastropods: Neritidae). Master of Science. Arts and Science University,

Rangoon.

Baconguis, S. 1991. Aquaculture technology: Key to mangrove swamp rehabilitation and sustainable coastal zone development in the Philippines. Canopy Internationa 17(6):5-12.

Bascompte, J., C.J. Melián, and E. Enric Sala. 2005. Interaction strength combinations and the overfishing of a marine food web. Proceedings of the National Academy of Sciences 102(15):5443-5447.

Bay of Bengal Large Marine Ecosystem Project. Web page. http://www.boblme.org/

Beffasti, L. 2010. Conservation and sustainable management of Lampi National Park. Report for Istituto Oikos and Biodiversity and Nature Conservation Association (BANCA). 58 pp.

Birdlife. Web page. http://www.birdlife.org

Bo Bo Kyaw. 2012. Taxonomic characters of sea cucumber species in Myeik environs, Tanintharyi Region. Master of Science. Myeik University.

Boer, W.F. 2007. Seagrass–sediment interactions, positive feedbacks and critical thresholds for occurrence: a review. Hydrobiologia 591(1):5-24.

Burke, L., K. Reytar, M. Spalding, and A. Perry. 2011. Reefs at Risk Revisited. Report for World Resources Institute. 115 pp.

Caughley, G. 1980. Crocodiles in Burma. Report for Food and Agriculture Organization. 13 pp.

Chandrasekaran, S., N. Arun Nagendran, D. Pandiaraja, N. Krishnankutty, and B. Kamalakannan. 2008. Bioinvasion of *Kappaphycus alvarezii* on corals in the Gulf of Mannar, India. Current Science (00113891) 94(9):1167-1172.

Chaw Su Lwin. 2012. Study on the genus *Lutjanus* (Family Lutjanidae) in Myeik coastal area. Master of Science. Myeik University.

Chaw Thiri Pyay Phyo Aye. 2012. Study on the compositions of meiofauna found in the patches of different algal species in Setse coastal area. Master of Research. University of Mawlamyine.

Cherry Aung. 2009a. Distribution of corals in the coastal zone of Myanmar. Journal of the Myanmar Academy of Arts and Science 7(5):449-468.

Cherry Aung. 2009b. Systematics and distribution of the hard corals (Cnidaria: Hydrozoa and Scleractinia) in the Myeik Archipelago coastal zone. Doctor of Philosophy. University of Mawlamyine.

Cho Cho Latt. 2010. Observations on the fisheries of anchovies (Engraulidae) of Setse Coast. Master of Science. Mawlamyine University.

Cho Cho Latt. 2011. Morphology and spore germination of the genus *Caloglossa* J. Agardh (Cermiales, Rhodophyta) from Setse and Kyaikkhami coastal areas. Master of Research. Mawlamyine University.

Cho Cho Lwin. 1997. The relationship between the length and weight and the fecundity of *Pampus argenteus*. Master of Science. University of Yangon.

Cho Cho Mar. 1988. Comparison of the neurocranial bones of some marine fishes. Master of Science. University of Yangon.

Cho Cho Myint. 1997. Some aspects of the reproductive biology of the estuarine blowfish *Tetraodon fluviatilis* Hamilton & Buchanan, 1822. Master of Science. University of Yangon.

Cho MeoI Aung. 2010. Insect pests in Chaung Tha mangrove and biology of some major pests and their natural enemies. Doctor of Philosophy. University of Yangon.

Clarke, S.C., M.K. McAllister, E.J. Milner-Gulland, G.P. Kirkwood, C.G.J. Michielsens, D.J. Agnew, E.K. Pikitch, H. Nakano, and M.S. Shivji. 2006. Global estimates of shark catches using trade records from commercial markets. Ecology Letters 9(10):1115-1126.

Conklin, E. and J. Smith. 2005. Abundance and spread of the invasive red algae, *Kappaphycus* spp., in Kane'ohe Bay, Hawai'i and an experimental assessment of management options. Biological Invasions 7(6):1029-1039.

Convention on Migratory Species. Web page. http://www.cms.int/species/

Convention on the International Trade in Endangered Species. Web page. CITES Species Database. http://www.cites.org/eng/disc/species.php

Das, I. 1997. Conservation of tropical Asia's most threatened turtles. *In* Conservation, Restoration, and Management of Tortoises and Turtles -- An International Conference. New York Turtle and Tortoise Society. New York. 295-301.

Davidson, L.N. 2012. Shark sanctuaries: subsistence or spin? Science 338(6114):1538-1539.

De Angelis, P. 2012. Assessing the impact of international trade on chambered nautilus. Geobios 45(1):5-11.

Department of Fisheries. 2010. Fishery statistics (2009-2010). Report. 100 pp.

Druzhinin, A.D. and Phone Hlaing. 1972. Observations on the trawl fishery of southern Burma. Proceedings of the Indo-Pacific Fish Council, 15th Session 13(3):151-209.

Duncan, P.M., J. Anderson, and J.G. De Man. 1889a. Contributions to the Fauna of Mergui and its Archipelago. Taylor and Francis, London. 312 pp.

Duncan, P.M., J. Anderson, and J.G. De Man. 1889b. Contributions to the Fauna of Mergui and its Archipelago. Taylor and Francis, London. 421 pp.

Ei Thandar Bol. 2013. Status of mangrove ecosystem conservation in Myanmar. Global Journal of Bioscience and Biotechnology 2(3):423-426.

FishBase. Web page. FishBase. http://www.fishbase.org/

Food and Agriculture Organization. Web page-a. Fishery Country Profile, The Union of Myanmar. ftp://ftp.fao.org/FI/DOCUMENT/fcp/en/FI_CP_MM.pdf

Food and Agriculture Organization. Web page-b. Food and Agriculture Aquatic Species Distributions. http://www.fao.org/fishery/collection/fish_dist_map/en

Food and Agriculture Organization. Web page-c. Food and Agriculture Information and Statistics Service. http://www.fao.org/fishery/statistics/en

Food and Agriculture Organization. Web page-d. Food and Agriculture List of Publications on Mangroves, Myanmar. http://www.fao.org/forestry/mangrove/3943/en/mmr/

Food and Agriculture Organization of the United Nations. 2003. Myanmar Aquaculture and Inland Fisheries Report. 60 pp.

Forestry Department of Myanmar and Japan International Cooperation Agency. 2005. The study on integrated mangrove management through community participation in the Ayeyawady Delta in the Union of Myanmar. Report. 55 pp.

Fritz, H.M., C. Blount, Swe Thwin, Moe Kyaw Thu, and Nyein Chan. Observations and Modeling of Cyclone Nargis Storm Surge in Myanmar *In* Solutions to Coastal Disasters. 1-9.

Gayder Kittim Ku. 2009. Shrimps and prawns of Pathein River. Doctor of Philosophy. Pathein University.

Giri, C., E. Ochieng, L.L. Tieszen, Z. Zhu, A. Singh, T. Loveland, J. Masek, and N. Duke. 2011a. Global Distribution of Mangroves. US Geological Survey.

Giri, C., E. Ochieng, L.L. Tieszen, Z. Zhu, A. Singh, T. Loveland, J. Masek, and N. Duke. 2011b. Status and distribution of mangrove forests of the world using earth observation satellite data. Global Ecology and Biogeography 20(1):154-159.

Global Biodiversity Information Facility. Web page. Global Biodiversity Information Facility Data Portal. http://data.gbif.org

Government of Burma. 1954. Fisheries Law.

Government of the Union of Myanmar. 1989a. Aquaculture Fisheries Law.

Government of the Union of Myanmar. 1989b. Law Relating to the Fishing Rights of Foreign Fishing Vessels.

Government of the Union of Myanmar. 1990. Myanma Marine Fisheries Law.

Government of the Union of Myanmar. 1992. Forest Law.

Government of the Union of Myanmar. 1993a. Law Amending the Law Relating to the Fishing Rights of Foreign Fishing Vessels.

Government of the Union of Myanmar. 1993b. Law Amending the Myanma Marine Fisheries Law.

Government of the Union of Myanmar. 1994. Protection of Wildlife and Wild Plants and Conservation of Natural Areas Law.

Guild, L., B. Ganapol, P. Kramer, R. Armstrong, A. Gleason, J. Torres, L. Johnson, and T. Garfield. 2003. Clues to coral reef ecosystem health: Spectral analysis coupled with radiative transfer modeling. *In* Eos Transactions American Geophysical Union. San Francisco, CA.

Han Ni Linn. 2010. Studies on the corals (Family:

Acroporidae) of Shwe Thaung Yan coastal region. Master of Science. Pathein University.

Harrison, L.R. and N.K. Dulvy. 2014. Sawfish: A Global Strategy for Conservation. Report. 110 pp.

Hart, G. 2009. Assessing the South-East Asian tropical lobster supply and major market demands. Report for Australian Centre for Intenational Agricultural Research. 55 pp.

Hexacorallians of the World. Web page. Hexacorallians of the World; Sea anemones, Corals, and their allies. http://hercules.kgs.ku.edu/Hexacoral/Anemone2/index.cfm

Hines, E., Mya Than Tun, L. Parr, D. Kwan, A. Novak, and Han Wen. 2007. Dugongs (*Dugong dugon*) along the Myeik Archipelago of Myanmar (2007). Report for Ocean Park Conservation Foundation. 28 pp.

Hla Hla Aye. 1996. The anatomy and histology of *Tectus niloticus maximus* (Philippi, 1814). University of Yangon.

Hla Hla Htay. 1994. The anatomy and the histology of *Coilia dussumieri* Cuv. & Val., 1848. Master of Science. University of Yangon.

Hla Hla Win. 2004. Taxonomic study on some marine fishes of Myeik environs. Master of Science. Myeik University.

Hla Hla Win. 2009. Floating cage culture of soft shelled mud crab *Scylla serrata* (Forskal, 1755) with the aspects of biology and economic importance in Myeik District, Taninthary Division. University of Yangon.

Hla Tint, Ma San San Oo, and Ko Myo Than. Salinity tolerance of some marine algae from Setse, Burma. *In* Burma Research Congress.

Hlaing Hlaing Oo. 2005. Studies on a conduting biopolymer film from a black tiger prawn (*Penaeus monodon*) shell waste. Doctor of Philosophy. University of Yangon.

Hlaing Hlaing Oo. 2012. Study on length weight relationship and fisher of *Tenualosa* spp. (Family - Clupeidae) from the Kyaikkhami coastal areas. Master of Science. University of Mawlamyine.

Hnin Ei Soe. 2011. Preliminary study on the spiny lobster in Setse and Kyaikkami coastal waters. Master of Science. Mawlamyine University.

Hnin Ei Soe. 2012. Observation on fishery status of Sciaenids (Family - Sciaenidae) from Panga, Yathaetaung, Setse and Kyaikkhami coastal areas. Master of Research. Mawlamyine University.

Hnin Khaing Aye. 2006. Preliminary study for sustainable mangrove forest management: Wunbaik Yambye Township, Rakhine State. Journal of the Myanmar Academy of Arts and Science 4(6):115-125.

Hnin Khaing Aye. 2007. Present situation of mangrove forest in Wunbaik Yambye Township, Rakhine State. Journal of the Myanmar Academy of Arts and Science 5(5):245-263.

Hnin Zar Htwe. 2012. Study on the fishery status of tunas and mackerels (Family Scombridae) in Myeik coastal waters. Master of Science. Myeik University.

Honey Shwe. 2012. Some aspects of biological measures of genus *Rastralliger*. Master of Science. Myeik University.

Htay Aung. 1982. The Taxonomy of some Panaeidae (Crustacea, Decapoda) from Mon State and Tenasserim Division coastal waters. Master of Science. Moulmein Degree College.

Htay Aung. 1987. Studies on the experimental pilot scale collections and growing of *C. belcheri* (Sowery) and *S. cucullata* (Born) at Setse, Thanbyuzayat Township, Mon State. Master of Science. Moulmein Degree College.

Htay Aung. 2004. Some decapod crustaceans and status of their fisheries in Myeik Archipelago. Journal of the Myanmar Academy of Arts and Science 2(2):236-252.

Htay Aung. 2009. Successful results in field cultivation of an exotic red seaweed species in Myeik Archipelago water and economic potentials. Journal of the Myanmar Academy of Arts and Science 7(5):347-362.

Htay Aung. 2011. Study on the spat collection and grow-out culture of oysters in Shwe Thaung Yan coastal area. Department of Marine Science. University of Mawlamyine.

Htay Htay Win. 1977. Some aspects of biology of *Parapenaeopsis hardwickii* Miers, 1878 (Crustacea) from Salween estuaries. Master of Science. Arts and Science University, Rangoon.

Htet Lynn Aung. 2012. Study on the seagrasses of

Wa-Maw Bay, Dawei District, Tanintharyi Region. Myeik University.

Htoo Thant. 1987. Preliminary studies on the induced maturation of *Penaeus monodon* (Fabricuius) (Crustacea: Decapoda). Master of Science. Moulmein Degree College.

Htwe Htwe Khine. 1999. Survey on the mastacembelids of Myanmar waters. Master of Science. University of Yangon.

Htwe Nyunt. 1996. Studies on the reproductive biology and hatchery culture of larvae of *Saccostrea cucullata* (Born) at Setse, Mon State, Myanmar. Master of Science. University of Mawlamyine.

Ilangakoon, A.D. 2007. Rediscovering the dugong (*Dugong dugon*) in Myanmar and capacity building for research and conservation. The Raffles Bulletin of Zoology 55(1):195-199.

IMaRS-USF and IRD. 2005a. Millennium Coral Reef Mapping Project (unvalidated maps are unendorsed by IRD, and were further interpreted by UNEP-WCMC). UNEP World Conservation Monitoring Centre, Cambridge (UK).

IMaRS-USF and IRD. 2005b. Millennium Coral Reef Mapping Project (validated maps). UNEP World Conservation Monitoring Centre, Cambridge (UK).

Indian Ocean and South-East Asian region [IOSEA]. 2009. Memorandum of Understanding on Conservation and Management of Marine Turtles and their Habitats of Indian Ocean and South-East Asia. 8 pp.

Integrated Taxonomic Information System. Web page. http://www.itis.gov/

Isituto Oikos. 2011. Myanmar Protected Areas; Context, Current Status and Challenges. Report for Istituto Oikos and Biodiversity and Nature Conservation Association (BANCA). 86 pp.

IUCN. Web page. IUCN Red List. http://www.iucnredlist.org/

Iverson, J.B. 1992. A revised checklist with distribution maps of the turtles of the world. Report for Privately printed. 363 pp.

Jackson, J.B.C., J.D. Cubit, B.D. Keller, V. Batista, K. Burns, H.M. Caffey, R.L. Caldwell, S.D. Garrity, C.D. Getter, C. Gonzalez, H.M. Guzman, K.W. Kaufmann, A.H. Knap, S.C. Levings, M.J. Marshall, R. Steger, R.C. Thompson, and E. Weil. 1989. Ecological effects of a major oil spill on Panamanian coastal marine communities. Science 243(4487):37-44.

Jar San. 2011. Studies on the morphology and distribution of cephalopods in Mon coastal areas. Master of Science. University of Mawlamyine.

Jar San. 2012. The morphology and spore germination of the genus *Polysiphonia* Greville (Ceramiales, Rhodophyta) from Setse and Kyaikkhami coastal areas. Master of Research. University of Mawlamyine.

Jefferson, T.A., M.A. Webber, and R.L. Pittman. 2008. Marine Mammals of the World; A Comprehensive Guide to their Identification. Academic Press, London. 573 pp.

Joffre, O. and Moe Aung. 2012. Prawn value chain analysis, Rakhine State, Myanmar. Report for Livelihoods and Food Security Trust Fund, Myanmar. 86 pp.

Kalayar Win Maung. 2007. Determination of age in relation to reproductive development of *Tenualosa ilisha* (Hamilton-Buchanan, 1822) and *Tenualosa toli* (Valencinnes, 1847). Doctor of Philosophy. University of Yangon.

Kathi Khine Soe. 2011. Study on some shrimp and prawn of Taninthayi River estuary, adjacent to Myeik. Master of Research. Myeik University, Department of Marine Science.

Kay Thi. 2009. Incubation period and hatching rate of sea turtle in relation to nest conditions. Doctor of Philosophy. University of Yangon.

Kay Thi, Htar Htar Kyi, Moe Moe Kyaw, and Theingi Soe Myint. 2011. Comparative study on hatching rate and incubation period of sea turtles from Kadongalay Island and Thameehla Island in Ayeyawady Regions and Oyster Island Rakhine State. Universities Research Journal (Myanmar) 4(2):11-23.

Kay Thwe Htwe. 2006. A study on induced spawning of Pearl Oysters, *Pinctada maxima* (Jameson, 1901), with various temperatures and salinities. Journal of the Myanmar Academy of Arts and Science 4(5A):205-215.

Kay Thwe Htwe. 2007. Induced spawning of pearl oyster, *Pinctada maxima* (Jameson, 1901), Pale-Kyun (Pearl Island), Taninthayi Division. Doctor of Philosophy. University of Yangon.

Kershaw, F., M. Leslie, T. Collins, R. Mansur, B.D. Smith, G. Minton, R. Baldwin, R. LeDuc, R.C. Anderson, R. Brownell Jr, and H.C. Rosenbaum. 2013. Population differentiation of 2 forms of Bryde's whales in the Indian and Pacific Oceans. Journal of Heredity 104(6):755-764.

Khaing Khaing Kyi. 2010. Impact of aquaculture farms on some aquatic species in the mangrove area of Pyinalan Reserved Forest, Ayeyarwaddy Delta. Doctor of Philosophy. University of Yangon.

Khaing Khaing Thein. 2008. Species composition of shark in Myanmar coastal waters and their relative abundance. Doctor of Philosophy. University of Yangon.

Khaing Myat Myat Htwe. 2012. Fishery biology of herring fishes at the Thanlywin River mouth and adjacent waters. Doctor of Philosophy. University of Mawlamyine.

Khin Htwe Yee. 2007. Identification of *Microbispora armeniacus* Nonomura and Ohara, 1971 isolated from *Holothuria pardalis* Selenka, 1867 and its antibacterial property. Doctor of Philosophy. University of Yangon.

Khin Htwe Yi. 2000. Biology and pond culture of *Penaeus monodon* Fabricius, 1798. Master of Science. University of Rangoon.

Khin Khin Gyi. 2010. The morphology and distribution of *Colpomenia sinuosa* (Mertens ex Roth) Derbes & Solier (Scyosiphonales, Phaeophyta) from Myanmar. Master of Science. University of Mawlamyine.

Khin Khin Htay. 1998. Survival and growth rates of *Penaeus monodon*. Master of Science. University of Rangoon.

Khin Khin Nwe. 1990. The anatomy and histology of *Ostracion cornutus* Linn., 1758. Master of Science. Dagon University.

Khin Khin San. 2010. Preliminary investigation on the Eel catfish (Family - Plotosidae) and Sea catfish (Family - Ariidae) common to Myeik waters. Master of Science. Myeik University.

Khin Maung Cho. 2009. A key to the species of grey mullet (Pisces: Mugillidae) in Mon and Ayeyarwady Division. Universities Research Journal (Myanmar) 2(3):343-370.

Khin Myat Myat Tun. 2000. Comparative morphological study of the alimentary canal of the cephalopods. Master of Science. University of Yangon.

Khin Myint Zin. 1984. The anatomy and histology of Mantis shrimp *Harpiosquilla raphidea* (Fabricius, 1798). Master of Science. Arts and Science University, Rangoon.

Khin Nwe Mu. 1980. A taxonomic study of some prawns from Ngawun River mouth, Bassein. Master of Science. Arts and Science University, Rangoon.

Khin Soe Nwe. 1979. The anatomy and some behavioural functions of Horse-shoe crab *Carcinoscorpius rotundicauda* (Latreille, 1802). Master of Science. Arts and Science University, Rangoon.

Khin Swe Thoung. 1977. The anatomy of *Polynemus paradiseus* Linnaeus, 1758. Master of Science. Arts and Science University, Rangoon.

Khin Thida Oo. 1994. The anatomy and histology of *Harpodon nehereus*. Master of Science. University of Yangon.

Khin Wai Hlaing. 2012. Crustacean fauna in mangrove areas, their habitat preference and assessment of human impacts in Mawlamying Kyun Township. Doctor of Philosophy. University of Yangon.

Khine Khine Lin. 1983. A study on the lateral line scales of some marine bony fishes. Master of Science. Arts and Science University, Rangoon.

Khit Latt Dwe. 2010. Morphology and distribution of family Rhizophoaceae in Thanbyuzayat Township. Master of Science. Mawlamyine University.

Ko Myint. 2005. The nesting behavior of Olive Ridley turtle (*Lepidochelys olivacea*) during 2003-2004 nesting season in Bogalay Township, Ayeyarwady Delta Region, Myanmar. Journal of the Myanmar Academy of Arts and Science 3(4):35-42.

Ko Myint. 2007. Ecology and nesting habits of sea turtles in Ayeyarwady Delta Region. Doctor of Philosophy. University of Yangon.

Ko Myint. 2009. Population assessment and nesting ecology of marine turtles in Ayeyarwady Delta region. Journal of the Myanmar Academy of Arts and Science 7(4):165-173.

Kumar, T.S., D.K. Jha, S.S. Jahan, G. Dharani, A.K.A. Nazar, M. Sakthivel, K. Alagaraja, M. Vijayaku-

maran, and R. Kirubagaran. 2010. Fishery resources of spiny lobsters in the Andaman Island, India. Journal of the Marine Biological Association of India 52(2):166-169.

Kyaw Kyaw Htay. 1985. Taxonomy of the marine fishes of Tavoy area. Master of Science. Arts and Science University, Rangoon.

Kyaw Kyaw Htay. 2010. Systematic and ecological study on deepsea fishes of Maungmagan coastal area, Tanintharyi Division. Doctor of Philosophy. University of Yangon.

Kyaw Min Naing. 2010. Studies of some Gray mullet (Pisces: Mugilidae) in Nga Wun River, Pathein District. Master of Science. Pathein University.

Kyaw Phone Lynn. 1979. The anatomy and histology of *Mystus vittatus* (Bloch, 1797) (Teleostomi: Bargridae). Master of Science. Arts and Science University, Rangoon.

Kyaw Thura. 2011. Study on the mangrove and its associated finfish of Myeik coastal area. Master of Research. Myeik University.

Kyaw Tint, O. Springate-Baginski, and Mehm Ko Ko Gyi. 2011. Community forestry in Myanmar: progress & potentials. Report, Ecosystem Conservation and Community Development Initiative, Yangon, Myanmar. 93 pp.

Kyaw Tint, Win Maung, and Tint Tun. 2012a. National situational analysis of sustainable management of coastal and marine ecosystems in Myanmar. Report, National Consultative Workshop on Conservation and Sustainable Management of Coastal and Marine Ecosystems in Myanmar. 21 pp.

Kyaw Tint, Win Maung, and Tint Tun. 2012b. National situational analysis of sustainable management of coastal and marine ecosystems in Myanmar. Presentation for the National Consultative Workshop on Conservation and Sustainable Management of Coastal and Marine Ecosystems in Myanmar. November 5-7, 2012.

Kyi Bin. 1979. The general anatomy of *Octopus rugosus* (Bosc, 1792) (Cephalopoda: Octopoda). Master of Science. Arts and Science University, Rangoon.

Kyi Kyi Maw. 2007. Population and habit of Mud crab, *Scylla serrata* (Forskal, 1775) in Bogalay and Laputta Townships, Ayeyarwady Division. Doctor of Philosophy. University of Yangon.

Kyi Kyi Myint. 1982. Studies on some aspects of biology of juvenile Peneidae from Damin Creek, Setse. Master of Science. Moulmein Degree College.

Kyi Win. 1972. A classified list of the seaweeds of Burma. *In* Burma Research Congress. 25-29.

Kyi Win. 1978. Extraction of liver oil from Hammer headed shark (*Sphyrna zygaena*) of Burma water and determination of vitamin A content and some characteristics of the oil. Master of Science. Arts and Science University, Rangoon.

Kyu Kyu Khin. 2005. The coastal environmental study of Chaung Tha area, Pathein West Township, Ayeyarwady Division. Master of Research. University of Yangon.

Kyu Kyu Than. 1978. A methodical study of gonadal condition in *Hilsa ilisha* (Hamilton, 1822) landed in the Keighly wholesale fish market and the Pyapon market. Master of Science. Arts and Science University, Rangoon.

Lack, M. and G. Sant. 2011. The Future of Sharks: A Review fo Action and Inaction. Report for Traffic and The Pew Environment Group. 41 pp.

Lay Min Naing. 2012. Study on the *Kappaphycus alvarezii* (Doty) Doty red seaweed cultivation and production at Sha Aww Bay, Elphinstone Island in Myeik coastal area. Master of Science. Myeik University.

Leatherwood, S., C. Peters, R. Santerre, M. Santerre, and J. Clarke. 1984. Observations of cetaceans in the northern Indian Ocean Sanctuary, November 1980 - May 1983. Reports of the International Whaling Commission 34:509-520.

Lei Lei Khine. 2007. Population dynamic of *Tenualosa ilisha* (Hamilton, 1822) in the offshore water of Ayeyarwaddy Division. Doctor of Philosophy. University of Yangon.

Leimgruber, P., D. Kelly, S., M.K. Steininger, J. Brunner, T. Müller, and M. Songer. 2005. Forest cover change patterns in Myanmar (Burma) 1990–2000. Environmental Conservation 32(04):356-364.

Limpus, C. 2012. Assessment of turtle conservation actions at Thameehla Island, Myanmar. Report for Marine Turtles - Indian Ocean and South-East Asia. 16 pp.

Livelihoods and Food Security Trust Fund. 2013. Tat

Lan Fisheries Working Paper. Report. 14 pp.

Locally Managed Marine Area Network. Web page. Resource center. http://www.lmmanetwork.org/resourcecenter

Ma Kyin Nwe. 1981. Studies on some aspects of the reproductive biology of *Scylla serrata* (Forskal, 1975). Master of Science. Moulmein Degree College.

Ma Lei Lei Win. 1990. Laboratory culture of brown alga, *Dictyota adnata* (Zanardini). Master of Science. Mawlamyine University.

Ma Myint Than. 1982. Experiments on environmental factor requirements of *Catenella* sp. Master of Science. Moulmein Degree College.

Ma Sein Mo Mo Hlaing. 2011. Study on the traditional grow out culture of sea bass *Lates calcarifer* (Bloch, 1790) in Yemyitkyi, Myeik area. Master of Science. Myeik University.

Maheswari, R.U. 2013. Mapping the under water habitat related to their bathymetry using Worldview-2 (wv-2) Coastal, Yellow, Rededge, Nir-2 Satellite imagery in Gulf of Mannar to conserve the marine resource. International Journal of Marine Science 3:91-97.

Malar Tun. 1997. The anatomy and histology of *Sillago domina* Cuv. & Val., 1829 (Teleostomi: Sillaginidae). Master of Science. University of Yangon.

Mar Lar Myo Sein. 1982. The taxonomy and distribution of Burmese marine bivalves. Master of Science. Arts and Science University, Rangoon.

Mar Mar Cho. 2006. Seasonal occurrence of prawn and shrimp caught by Kyar-Net near Pyinkayaing (Ngaputaw Township: Ayeyarwady Division). Master of Science. Pathein University.

Marsh, H. 2002. Dugong status report and action plan for countries and territories. Report for United Nations Environment Programme (UNEP). 163 pp.

Martin, G.V. 1871. List of algae collected by Mr. S. Kutz in Burma and adjacent islands. Proceedings of the Asiatic Society of Bengal:461-469.

Mason, F. 1852. Tenasserim, or, Notes on the Fauna, Flora, minerals, and nations of British Burmah and Pegu: With Systematic Catalogues of the Known Minerals, Plants, Mammals, Fishes, Mollusks, Sea-nettles, Corals, Sea-urchins, Worms, Insects, Crabs, Reptiles, and Birds, with Vernacular Names. First edition. American Mission Press. 712 pp.

Mason, F. 1860. Burmah, its People and Natural Productions, or, Notes on the Nation's Fauna, Flora and Minerals of Tenasserim, Pegu and Burmah: With Systematic Catalogues of the Known Mammals, Birds, Fish, Reptiles, Insects, Mollusks, Crustaceans, Annelids, Radiates, Plants and Minerals, with Vernacular Names. Second edition. Thos. Stowe Ranney, Rangoon. 913 pp.

Mason, F. 1882. Burma, It's People and Productions; Or Notes on the Fauna, Flora and Minerals of Tenasserim, Pegu and Burma. Third edition. Stephen Austin & Sons, Hertford. 560 pp.

Maung Bo. January, 2004. Current development in pearl culture and pearl production of Myanmar. *In* Myeik Forum.

Maung Hla and Thein Thein Kyi. 2012. Shark and rays species identification in Myanmar. *In* Regional Workshop on Taxonomy and Identification of Shark and Rays in Southeast Asia. Kuala Terengganu, Malaysia.

Maung Maung Kyaw. 2012. Reviews on the implementation of natural forests and forest plantation management from 2001-02 to 2010-11 under National Forestry Master Plan (Myanmar Language). Report for Forest Department, Myanmar.

Maung Maung Lwin. 2007. Tagging activities of Olive Ridley turtle at Gadongalay and Gayetgyi Islands, Bogalay Township in Ayeyarwady Division, Myanmar. *In* 4th International Symposium on SEASTAR2000 and Asian Bio-logging Science (The 8th SEASTAR2000 Workshop), December 15-17, 2007. Phuket, Thailand. 3-6.

Maung Maung Lwin. 2009a. Green turtle (*Chelonia mydas*) nesting and conservation activity in Thameehla Island, Myanmar. Indian Ocean Turtle Newsletter(10):14-18.

Maung Maung Lwin. 2009b. Tagging study on Green turtle (*Chelonia mydas*) at Thameehla Island, Myanmar. *In* 5th International Symposium on SEASTAR2000 and Asian Bio-logging Science (The 9th SEASTAR2000 Workshop), March 5-6, 2009. Bangkok, Thailand. 15-19.

Maung Maung Winn. 1974. A systematic study of some elasmobranchs of Zeebyuthaung. Master of Science. Arts and Science University, Rangoon.

Maw Maw Myint, Soe Soe Aye, Hla Win Zaw, Maw Maw Lin, Soe Than, Win Win Si, and Soe Naing. 2004. Taxonomic study on some marine crustaceans of Myeik environs (2003 - 2004). Report for Myeik University.

Maw Maw Than. 1991. The study of some commercially important by-catch dicarded fishes from shrimp fishery in Rakhine Coast (1990-91). Master of Science. University of Yangon.

Maxwell, F.D. 1911a. Report on the inland and sea fisheries in the Thongwa, Myaungmya, and Bassein Districts and the Turtle Banks of the Irrawaddy Division. Report for Government Printing Office, Rangoon. 57 pp.

Maxwell, F.D. 1911b. Report on the turtle-banks of the Irrawaddy Division. Report, Government Printing Office, Rangoon. 57 pp.

May Khin Htun. 2005. Quality assessment of Ka-Ku-Yan (*Polynemus indicus*), Nga-Mote-Phyu (*Pampus argenteus*) and Nga-Mote-Mei (*Parastomateus niger*) for export. Doctor of Philosophy. University of Yangon.

May Soe Oo. 1994. The anatomy and histology of *Rastrelliger kanagurta* (Cuv, 1817). Master of Science. University of Yangon.

May Soe Thu. 1997. Taxonomy and distribution of marketable offshore fishes caught from Myanmar waters. Master of Science. University of Yangon.

May Thet Htar Aung. 1983. A study on the teeth of some bony marine fishes. Master of Science. Arts and Science University, Rangoon.

May Win Maw. 2005. Ichthyological survey on some marine fishes of Ngwe Saung coastal area. Master of Research. Dagon University.

Mendez, M., T. Jefferson, S.-O. Kolokotronis, M. Krützen, G. Parra, T. Collins, G. Minton, R. Baldwin, P. Berggren, A. Särnblad, O. Amir, V. Peddemors, L. Karczmarski, A. Guissamulo, B.D. Smith, G. Amato, H.C. Rosenbaum, and D. Sutaria. In press. Integrating multiple lines of evidence to better understand the evolutionary divergence of humpback dolphins along their entire distribution range: a new dolphin species in Australian waters? Molecular Ecology.

Mendez, M., T.A. Jefferson, S.-O. Kolokotronis, M. Krützen, G.J. Parra, T. Collins, G. Minton, R. Baldwin, P. Berggren, A. Särnblad, O.A. Amir, V.M. Peddemors, L. Karczmarski, A. Guissamulo, B. Smith, D. Sutaria, G. Amato, and H.C. Rosenbaum. 2013. Integrating multiple lines of evidence to better understand the evolutionary divergence of humpback dolphins along their entire distribution range: a new dolphin species in Australian waters? Molecular Ecology.

Mg Mg Gyi. 1993. The anatomy and histology of the Hermit crab *Pagurus euopsis* (Crustacea: Anomura). Master of Science. University of Yangon.

Mie Mie Sein. 2006a. A study on the gill structure and its histology in some marine teleosts. Master of Science. University of Yangon.

Mie Mie Sein. 2006b. Study on two Mud crabs, *Scylla* spp. (Forskal, 1755), in correlation with the ecosystem of Ye-Chan-Pyin mangrove area, Sittway Township, Rakhine State. Doctor of Philosophy. University of Yangon.

Min Thu Aung. 2006. Population dynamics and the effect of fishing gears inshore fishing grounds of Kawthoung District, Tanintharyi Division. Doctor of Philosophy. University of Yangon.

Ministry of Education, M. Web page. http://www.myanmar-education.edu.mm/

Ministry of Hotels and Tourism. 2012. Responsible Tourism Policy. Report for Government of the Republic of the Union of Myanmar. 24 pp.

Ministry of Hotels and Tourism. 2013. Policy on Community Involvement in Tourism (CIT). Report. 48 pp.

Moe Lwin Lwin. 2012. Study on some marine green algae (Phylum - Chlorophyta) of Warr-Kyun and Sin-Kyun, Tanintharyi coastal region. Master of Science. Myeik University.

Moe Sapai. 1998. Comparative osteology of the pectoral girdle, pelvic girdles and fins of some marine fishes. Master of Science. University of Yangon.

Moe Swe. 2012. Study on the supplementary diet on the growth of *Penaeus monodon* larvae under laboratory condition. Master of Science. Pathein University.

Moe Thida Htway. 2003. Comparative histology on some internal organs of seabass, *Lates calcarifer* (Bloch, 1790) and *Labeo rohita* (Hamilton, 1822). Master of Research. University of Yangon.

Moh Moh Win. 1988. The anatomy and histology

of *Caranx affinis* Ruppelli, 1835 (Family Carangidae). Master of Research. Arts and Science University, Rangoon.

Moll, E. and E.O. Moll. 2004. The Ecology, Exploitation, and Conservation of River Turtles. Oxford University Press, Oxford. 393 pp.

Moll, E.O., K. Platt, S.G. Platt, P. Praschag, and P.P. van Dijk. 2009. *Batagur baska* (Gray 1830) - Northern River Terrapin. Conservation biology of freshwater turtles and tortoises: A compliation project of the IUCN/SSC Tortoise and Freshwater Turtle Specialist Group. Pages 037.031-037.010.

Mu Mu Aye. 1982. Experiments on environmental factor requirements of *Gracilaria* species. Master of Science. Moulmein Degree College.

Mumby, P.J., C.P. Dahlgren, C.P., A.R. Harborne, C.V. Kappel, F. Micheli, D.R. Brumbaugh, K.E. Holmes, J.M. Mendes, K. Broad, J.N. Sanchirico, K. Buch, S. Box, R.W. Stoffle, and A.B. Gill. 2006. Fishing, trophic cascades, and the process of grazing on coral reefs. Science 311:99-101.

Mumby, P.J. and A.J. Edwards. 2002. Mapping marine environments with IKONOS imagery: enhanced spatial resolution can deliver greater thematic accuracy. . Remote Sensing of Environment 82:248–257.

Mya Kyawt Wai. 2008. Studies on the genus *Padina* (Dictyotales: Phaeophyta) of Myanmar. Master of Research. University of Mawlamyine.

Mya Kyawt Wai and Soe Htun. 2008. Studies on the morphology and distribution of *Padina boryana* Thivy (Dictyotales, Phaeophyta) from Myanmar. Universities Research Journal (Myanmar) 1(4):335-348.

Mya Kyawt Wai and Soe Htun. 2009. Studies on the morphology and distribution of *Padina antillarum* (Kiizing) Piccone (Dictyotales, Phaeophyta) from Myanmar. Universities Research Journal (Myanmar) 2(3):323-342.

Mya Kyawt Wai, Thida Nyunt, Soe Pa Pa Kyaw, and Soe Htun. 2009a. Marine algae of Mazin coastal areas, Thandwe Township, Rakhine State. Journal of the Myanmar Academy of Arts and Science 7(5):1-23.

Mya Kyawt Wai, Thida Nyunt, Soe Pa Pa Kyaw, and Soe Htun. 2009b. The morphology and distribution of the genus *Avrainvillea* (Bryopsidales, Chlorophyta) from Myanmar. Journal of the Myanmar Academy of Arts and Science 7(5):199-212.

Mya Kyawt Wai, Thida Nyunt, Soe Pa Pa Kyaw, and Soe Htun. 2009c. The morphology and distribution of the genus *Codium* (Bryosidales, Chlorophyta) from Myanmar. Journal of the Myanmar Academy of Arts and Science 7(5):183-198.

Mya Kyawt Wai, Thida Nyunt, Soe Pa Pa Kyaw, and Soe Htun. 2009d. A new record of the genus *Titanophora* (Pchizymeniaceae, Nemastomatales) from Myanmar. Journal of the Myanmar Academy of Arts and Science 7(5):253-262.

Mya Marlar Chan Tun. 1977. Microbiology of Hilsa. Master of Science. Arts and Science University, Rangoon.

Mya Mya Htwe. 1995. The anatomy and histology of *Lambis lambis* (Linnaeus, 1758). Master of Science. University of Yangon.

Mya Saw. 1975. The anatomy of *Nemipterus japonicus* (Bloch, 1791). Master of Science. Arts and Science University, Rangoon.

Mya Than Tun and Tint Tun. 2002. A preliminary observation on coral reefs in Kawthoung Township. Europe Conservation Switzerland (ECoSwiss)

Myanmar Ministry of Livestock and Fisheries. 2008a. Fishery Statistics (2007 - 2008). Report. 91 pp.

Myanmar Ministry of Livestock and Fisheries. 2008b. Statistic of Exported Fish and Fishery Products from Myanmar (2007 - 2008). Report. 76 pp.

Myanmar Ministry of National Planning and Economic Development. 2010. Livestock and Fisheries Statistics (2008 - 2009). Report. 193 pp.

Myint Myint Cho. 1980. Studies on extraction methods, variations in yield and viscosity of some Burmese sodium alginate. Master of Science. Moulmein College.

Myint Myint Cho. 2011. Small-scale extraction of alginate compounds from some brown seaweeds of Myanmar. Doctor of Philosophy. University of Mawlamyine.

Myint Myint Cho and Thida Nyunt. 2009. The diversified utility of carageenan extracts derived from some red algae. Universities Research Journal

(Myanmar) 2(3):285-303.

Myint Myint Kyi. 1994. The anatomy and histology of *Trichiurus savala* Cuv., 1829. Master of Science. University of Yangon.

Myint Pe. 2003. National Report of Myanmar on the Sustainable Management of The Bay of Bengal Large Marine Ecosystem (BOBLME). Report for Department of Fisheries, Myanmar. 61 pp.

Myint Sein and Bo Ni. 2009. Report on Study Tour to Lampi Marine National Park, Mergui Archipelago, Myanmar. Report. 20 pp.

Myo Min Hlaing. 1999. Comparative study on the metamorphosis of *Penaeus monodon* Fabricius, 1798 larvae in relation to environmental condition. Master of Science. University of Yangon.

Myo Nandar Myint. 2012. Study on the morphometric characters and length weight relationship of *Harpiosquilla raphidea* (Mantis shrimp) in Myeik coastal waters. Master of Science. Myeik University.

Nan Nwe Nwe Aye. 1998. On the systematic and ecological aspects of some gastropods and pelecypods of Wet-the and Chaungtha areas (Pathein Township, Thabaung Township, Ayeyarwady Division). Master of Science. University of Yangon.

Nang Mya Han. 1985. Some aspects of the biology of Tetraodontidae (Pisces - Gymnodoniformes) from Setse. Master of Science. Moulmein Degree College.

Nang Mya Han. 2008. Study on the status of marine mammals (Cetacean) of Tanintharyi coastal waters. Journal of the Myanmar Academy of Arts and Science 6(4):151-174.

Nang Mya Han. 2009a. Preliminary investigation on the Myanmar Yay-thu-ma or Yaywet of Dugong in Myanmar waters and conservation needs. Journal of the Myanmar Academy of Arts and Science 7(5):499-513.

Nang Mya Han. 2009b. Study on the status of the marine environment of Myeik Archipelago and conservation needs. Universities Research Journal (Myanmar) 2(3):371-384.

Nang Mya Han. 2011a. Overview on the needs of public awareness for sustainable development in Tanintharyi Coastal urban areas. Report. 30 pp.

Nang Mya Han. 2011b. A study on the public awareness and the status of action plan for mitigation of coastal and marine environment of Mergui Archipelago. Universities Research Journal (Myanmar) 4(2):277-306.

Nang Mya Han. 2012. Study on the sea cucumber and sea cucumber fisheries of Myeik Archipelago, Taninthayi Region. Universities Research Journal (Myanmar) 5:1-24.

Nant Nay Chit Latt. 2009. Species occurrence of shrimps and prawns of Meinmahla Kyun Wildlife Sanctuary, Ayeyarwady Division. Master of Research. Dagon University.

National Biodiversity Strategy and Action Plan. 2011. National Biodiversity Strategy and Action Plan. Page 135. 135.

National Oceanic and Atmospheric Administration. Web page. Oil spills can be very harmful to marine birds and mammals as well as fish and shellfish. http://oceanservice.noaa.gov/facts/oilimpacts.html

Naung Naung Oo. 2012. Study on the marine gastropods from Mon coastal areas. Master of Research. University of Mawlamyine.

Naw Le Le Hnin. 1980. Studies on methods of extraction, variations in some physical properties and yields of Burmese agar-agar and carrageenan. Master of Science. Moulmein Degree College.

Nay Win Oo. 2004. Changes in Habitat Conditions and Conservation of Mangrove Ecosystem in Myanmar: A Case Study of

Pyindaye Forest Reserve, Ayeyarwady Delta. Report for MAB Young Scientist Award. 15 pp.

New York Times. 2008. Farmed algae choking coral in Kiribati. http://www.nytimes.com/2008/07/08/world/asia/08iht-coral.1.14326732.html?pagewanted=all&_r=0

Ngu War Hlaing. 2010. Studies on the morphology of some commercial marine fishes from Mawlamyine markets. Master of Science. Mawlamyine University.

Novak, A.B., E. Hines, D. Kwan, L. Parr, Mya Than Tun, Han Win, and F.T. Short. 2009. Revised ranges of seagrass species in the Myeik Archipelago, Myanmar. Aquatic Botany 91(3):250-252.

Nu Mya Than. 1983. The biology of the fishes of the Family Nemipteridae and Mullidae caught by

trawl net off the Arakan Coast of Burma. Master of Science. Arts and Science University, Rangoon.

Nu Nu Aye. 1984. Morphology of the pectoral girdle of some marine fishes. Master of Science. Arts and Science University, Rangoon.

Nwe Nwe Ni. 1998. Investigation on the grow out farming of *Penaeus monodon* Fabricius, 1798. Master of Science. University of Yangon.

Nwe Nwe Win. 1986. The reproductive biology of *Sardinella fimbriata* (Nga-Kon-Nyo) along the Sandoway Township. Master of Science. Arts and Science University, Rangoon.

Nyein Phyu The'. 2005. Study on some economic potential fish speicies in the vicinity of Hainggye Island, Ayeyarwady Division. Master of Research. Dagon University.

Nyo Nyo San. 2011. Study on the mangrove plants of Kalagoke Island, Ye Township. Master of Research. Mawlamyine University.

Nyo Nyo Than. 1987. Anatomy and histology of *Scatophagus argus* (Linnaeus, 1788). Master of Science. Arts and Science University, Rangoon.

Obura, D., Zau Lunn, and S. Benbow. 2014. Coral diversity and reef resilience in the northern Myeik Archipelago, Myanmar. Report for Flora and Fauna International. 53 pp.

Ocean Biogeographic Information System. Web page. Ocean Biogeographic Information System. http://www.iobis.org

Ohm Mar Myin. 1989. The anatomy and histology of *Pampus sinensis* (Euphares, 1788). Master of Science. University of Yangon.

Ohn. 1992. Report on mangrove forest products and utilization of the Ayeyarwady Delta (English) Report.

Ohn Mar Han. 1996. The anatomy and histology of *Therapon jarbua* (Forstal, 1775). Master of Science. University of Yangon.

Ohn Mar Myat Oo. 2008. The impact of the economic activities on mangrove environment in Taungup Township. Doctor of Philosophy. University of Yangon.

Okamoto, I. 2008. The shrimp export boom and small-scale fishermen in Myanmar. IDE Discussion Paper 135:1-21.

Ooi, J.L.S., G.A. Kendrick, K.P. Van Niel, and Y.A. Affendi. 2011. Knowledge gaps in tropical Southeast Asian seagrass systems. Estuarine, Coastal and Shelf Science 92(1):118-131.

Pain, D., R. Green, and N. Clark. 2001. On the edge: can the Spoon-billed Sandpiper be saved? British Birds 104:350-363.

Pauly, D. and S. Aung. 1984. Population Dynamics of some fishes of Burma based on length-frequency data. Report for Food and Agriculture Organization. 22 pp.

Phu Pwint Zin. 2012. The morphology of *Gelidium* spp. from Kyaikkhami and Setse coastal areas. Master of Science. University of Mawlamyine.

Phyu Phyu Khin Win. 1990. Taxonomic studies on some molluscs trawled off-shore in Myanmar waters. Master of Science. University of Yangon.

Phyu Phyu Sin. 1983. A study on the caudal appendages of some estuarine fishes. Master of Science. Arts and Science University, Rangoon.

Phyu Phyu Than. 2012. Investigation on gastropods and pelecypods in mudflats and sandy beach around Myeik environs, Tanintharyi region. Master of Science. Myeik University.

Phyu Phyu Win. 1992. The anatomy and histology of *Lutijanus quinquelinearis* (Bloch, 1790). Master of Science. University of Yangon.

Platt, K., S.G. Platt, K. Thirakhupt, and T.R. Rainwater. 2008. Recent records and conservation status of the critically endangered Mangrove Terrapin, *Batagur baska*, in Myanmar. Chelonian Conservation and Biology 7(2):261-265.

Platt, S.G., K. Platt, Khin Myo Myo, and Me Me Soe. 2014. An Ecological Reconnaissance of Lampi Island Marine National Park, Myanmar. Report for Wildlife Conservation Society and Turtle Survival Alliance. 47 pp.

Platt, S.G., Win Ko Ko, and Khin Myo Myo. 2013. Husbandry and conservation at Thaketa crocodile farm, Myanmar. Crocodile Specialist Group Newsletter 32(1):17-20.

Pont Pont Phyu. 1992. A systematic study of some deepsea prawns. Master of Science. University of Yangon.

Poole, C. 2010. Swiftlet farming comes to Cambodia.

Praschag, P., A.K. Hundsdörfer, and U. Fritz. 2007. Phylogeny and taxonomy of endangered South and South-east Asian freshwater turtles elucidated by mtDNA sequence variation (Testudines: Geoemydidae: *Batagur*, *Callagur, Hardella, Kachuga, Pangshura*). Zoological Scripta 36(5):429-442.

Rao, M., Saw Htun, S.G. Platt, R. Tizard, C. Poole, Than Myint, and J.E.M. Watson. 2013. Biodiversity conservation in a changing climate: A review of threats and implications for conservation planning in Myanmar. Ambio:1-16.

Reeves, R.R., K. McClennan, and T.B. Werner. 2013. Marine mammal bycatch in gillnet and other entangling net fisheries, 1990 to 2011. Endangered Species Research 20(1):71-97.

Roberts, T.R. 2001. *Ayarnangra estuarius*, a new genus and species of sisorid catfish from the Ayeyarwaddy Basin, Myanmar. Natural History Bulletin of the Siam Society 49(1):81-87.

Robson, C. 2008. A Field Guide to the Birds of Thailand and South-east Asia. Asia Books Co., Ltd., Bangkok.

Royal Navy Bird Watching Society. Web page. A field guide to the birds of Thailand and South-east Asia. http://www.rnbws.org.uk

Sabai Soe. 2012. Some aspects of biological measures of Tonguesoles (Family - Cynoglosidae) found in Myeik area. Master of Science. Myeik University.

San Aung and Hla Htay. 1986. Marine fishes, prawns, shrimps and lobsters of Burma collected from trawling surveys. *In* Burma Research Congress.

San San Aye. 2007. Rearing of the Pearl oyster *Pinctada maxima* (Jameson, 1901) larvae at Pale Kyun (Pearl Island) in Taninthayi Division. Doctor of Philosophy. University of Yangon.

San San Khine. 2010. Species diversity, population abundance and reporductive condition of elasmobrach species from the Ayeyarwady Division. Doctor of Philosophy. University of Yangon.

San San Win. 1993. Taxonomy and distribution of Myanmar marine coelenterates (Cnidaria). Master of Science. University of Yangon.

San San Yi. 1997. A comparative on the structure and function of the eyes of some selected crustaceans. Master of Science. University of Yangon.

San Tha Tun. 1990. Laboratory culture of the red alga, *Laurencia*. Master of Science. University of Mawlamyine.

San Tha Tun. 2011. Species composition and structure of mangrove community along the U-To tidal creed in Chaung Tha. Doctor of Philosophy. University of Mawlamyine.

San Tha Tun, Tint Swe, and Tint Tun. 2008. Preliminary study on the mangroves of Lampi Island and adjacent areas. Report for Europe Conservation Switzerland (ECoSwiss) and Biodiversity and Nature Conservation Association (BANCA). 19 pp.

Sandar Win. 2009. Community ecology of gastropods and pelecypods along Chaung Tha coastal area. Doctor of Philosophy. University of Yangon.

Sandar Win. 2011. The Assessment on the diversity of gastropods and pelecypods along Chaungtha coastal area. Journal of the Myanmar Academy of Arts and Science.

Sandar Win and Khin Maung Swe. 2011. Seasonal abundance of gastropods along Chaughtha coastal area. Universities Research Journal (Myanmar) 4(2):117-131.

Saw Han Shein, Tint Tun, Tint Wai, and Thaung Htut. 2010. Research report of Lampi Island field trip (plankton, seaweed and seagrass). Report. 51 pp.

Saw Htoo Baw. 1978. The anatomy of *Scylla serrata* (Forskal, 1775) De Mann, 1833 (Decapoda). Master of Science. Arts and Science University, Rangoon.

Saw Nanda. 2000. Structure of dentition and alimentary canal in relation to the feeding habits of some marine fishes. Master of Science. University of Yangon.

Sciberras, M., S.R. Jenkins, R. Mant, M.J. Kaiser, S.J. Hawkins, and A.S. Pullin. 2013. Evaluating the relative conservation value of fully and partially protected marine areas. Fish and Fisheries.

Seim Moh Moh Hlaing. 2012. Some aspects of biology of *Johnius belangerii* (Cuvier, 1830) Family; Scianenidae, in Myeik area. Master of Research. Myeik University.

Sein Moh Moh Khaing. 2011. Studies on the processing methods and utilization of surmi products from some tropical edible fishes and prawns. Master of Science. University of Mawlamyine.

Sein Moh Moh Khaing. 2012. Studies on the marine benthic algae of Kyaikkhami coastal areas. Master of Research. University of Mawlamyine.

Sein Thiri Htwe. 2012. Study on the goatfish (Family Mullidae) in Myeik coastal area. Master of Science. Myeik University.

Short, F.T. 2005. Global distribution of seagrasses (V2.0, 2005) UNEP World Conservation Monitoring Centre, Cambridge (UK).

Si Thu Hein. 2011. Study on polychaete diversity in some intertidal mud flat of Myeik area. Master of Research. Myeik University.

Smith, B.D. 2005. Preliminary report on a training course for South Asian scientists on cetacean population assessment techniques and a survey for cetaceans in the coastal waters of the Mergui (Meik) Archipelago, Myanmar. Report. 5 pp.

Smith, B.D. and Aung Myo Chit. 2011. Final report on the status and conservation of coastal populations of Irrawaddy Dolphins in Myanmar. Report. 24 pp.

Smith, B.D., Hpone Thant, Johnny Min Lwin, and C.D. Shaw. 1997. Status of Irrawaddy dolphins Orcaella brevirostris in the upper reaches of the Ayeyarwaddy River, Myanmar

. Asian Marine Biology 14:173-194.

Smith, B.D. and Mya Than Tun. 2008. A note on the species occurrence, distributional ecology and fisheries interactions of cetaceans in the Mergui (Myeik) Archipelago, Myanmar Journal of Cetacean Research and Management 10(1):37-44.

Smith, B.D., R.D. Shore, and A. Lopez. 2007. Status and conservation of freshwater populations of Irrawaddy dolphins. Report for Wildlife Conservation Society. 115 pp.

Smythies, B.E. 2001. The Birds of Burma. Fourth edition. Natural History Publications, Sabah, Malaysia. 432 pp.

Soe Htun. 1998. The Seaweed resources of Myanmar. *In* A. Crithley, M. Ohno, D. Largo, and R. Gillespie, editors. Seaweed Resources of the World. Japan International Cooperation Agency. Pages 99-106.

Soe Htun and Ko Zaw Zaw Pe. Studies on cultivation of conchocelis filaments in *Porphyra crispata* Kjellman. *In* Burma Research Congress.

Soe Htun, Ma Htay Htay Mon, and Ko Win Latt. Observation on seasonal variations of vegetative growth and spore formation of *Catenella*. *In* Burma Research Congress.

Soe Htun, Mya Kyawt Wai, Thida Nyunt, Soe Pa Pa Kyaw, and Mu Mu Aye. 2009a. Notes on some marine benthic algae of Gwa coastal areas: Phaeophyta (brown algae). Journal of the Myanmar Academy of Arts and Science 7(5):87-114.

Soe Htun, Mya Kyawt Wai, Thida Nyunt, Soe Pa Pa Kyaw, and Mu Mu Aye. 2009b. Seagrasses of Myanmar with Special Reference to the Phytogeographic Distribution of the Species of ASEAN Nations. Journal of the Myanmar Academy of Arts and Science 7(5):363-388.

Soe Htun, Mya Kyawt Wai, Thida Nyunt, Soe Pa Pa Kyaw, Yin Yin Htay, and Mu Mu Aye. 2009c. Checklist, distribution and potential utilization of marine algae of Myanmar II: Rhodophyta (Red Algae). Journal of the Myanmar Academy of Arts and Science 7(5):279-306.

Soe Htun, Myat Kyawt Wai, Thida Nyunt, Soe Pa Pa Kyaw, and Mu Mu Aye. 2009d. Notes on some marine benthic red algae of Gwa coastal areas I: Rhodophyta (Goniotrichales, Stylonematales, Erythropeltidales, Bangiales, Acrochaetiales, Nemaliales, Corallinales, Gelidiales and Halymeniales). Journal of the Myanmar Academy of Arts and Science 7(5):115-142.

Soe Htun, Myawt Kyawt Wai, Thida Nyunt, Soe Pa Pa Kyaw, and Mu Mu Aye. 2009e. Notes on some marine benthic red algae of Gwa coastal areas II: Rhodophyta (Cryptonemiales, Gigartinales, Gracilariales, Rhodymeniales and Ceramiales). Journal of the Myanmar Academy of Arts and Science 7(5):143-182.

Soe Htun, Myawt Kyawt Wai, Thida Nyunt, Soe Pa Pa Kyaw, Yin Yin Htay, and Mu Mu Aye. 2009f. Checklist, distribution and potential utilization of marine algae of Myanmar I: Chlorophyta (Green algae) and Phaeophyta (Brown algae). Journal of the Myanmar Academy of Arts and Science 7(5):263-278.

Soe Htun, Myawt Kyawt Wai, Thida Nyunt, Soe Pa Pa Kyaw, Yin Yin Htay, and Mu Mu Aye. 2009g. Checklist, distribution and potential utilization of marine algae of Myanmar II: Rhodophyta (Red algae). Journal of the Myanmar Academy of Arts and Science 6(8):177-194.

Soe Htun, San Tha Htun, Mu Mu Aye, Ni Ni Win, Lei Lei Win, and M. Ohno. 2001. Notes on Seagrasses along Myanmar Coastal Regions. Bulletin of marine sciences and fisheries, Kochi University 21:13-22.

Soe Moe Htun. 2010. Studies on the biology of *Polynemus paradiseus* Linnaeus from the Thanlwin River mouth. Master of Science. Mawlamyine University.

Soe Pa Pa Kyaw. 2008. Studies on the genus *Dictyota* (Dictyatale, Phaeophyta) of Myanmar. Master of Research. Mawlamyine University.

Soe Pa Pa Kyaw, Mya Kyawt Wai, Thida Nyunt, Mu Mu Aye, and Soe Htun. 2009a. Effects of light intensity on the formation and growth of the secondary branches of *Dictyota adnata* Zanardini grown in different salinity and temperature regimes. Journal of the Myanmar Academy of Arts and Science 7(5):321-332.

Soe Pa Pa Kyaw, Mya Kyawt Wai, Thida Nyunt, Mu Mu Aye, and Soe Htun. 2009b. Effects of light quality on the formation and growth of the secondary branches of *Dictyota adnata* Zanardini Grown in different salinity and temperature regimes. Journal of the Myanmar Academy of Arts and Science 7(5):307-320.

Soe Pa Pa Kyaw, Mya Kyawt Wai, Thida Nyunt, Mu Mu Aye, and Soe Htun. 2009c. Notes on some marine benthic algae of Gwa coastal areas: Chlorophyta (green algae). Journal of the Myanmar Academy of Arts and Science 7(5):39-86.

Soe Pa Pa Kyaw, Mya Kyawt Wai, Thida Nyunt, Mu Mu Aye, and Soe Htun. 2009d. Some observations on the daily growth rate of the agarophytes, *Gracilaria gracilis, G. canaliculata* and *Hydropuntia edulis* (Gracilariales, Rhodophyta) from Kyaikkhami and Setse, Mon State. Journal of the Myanmar Academy of Arts and Science 7(5):333-346.

Soe Pa Pa Kyaw, Mya Kyawt Wai, Thida Nyunt, and Soe Htun. 2009e. The morphology and distribution of *Canistrocarpus cervicornis* (Kutizing) De Paula & De Clerck (Dictyotales, Phaeophyta) from Myanmar. Journal of the Myanmar Academy of Arts and Science 7(5):213-226.

Soe Pa Pa Kyaw, Mya Kyawt Wai, Thida Nyunt, and Soe Htun. 2009f. The morphology and distribution of *Dictyopteris woodwardia* (Brown & Turner) C. Agardh (Dictyotales, Phaeophyta) from Myanmar. Journal of the Myanmar Academy of Arts and Science 7(5):227-238.

Soe Pa Pa Kyaw, Mya Kyawt Wai, Thida Nyunt, and Soe Htun. 2009g. The morphology and distribution of *Stoechospernum polypodioides* (Lamouroux) J. Agardh (Dictyotales, Phaeophyta) from Myanmar. Journal of the Myanmar Academy of Arts and Science 7(5):239-252.

Soe Pa Pa Kyaw and Soe Htun. 2008. Studies on the morphology and distribution of *Dicyota indica* Anand (Dictyotales, Phaeophyta) from Myanmar. Universities Research Journal (Myanmar) 1(4):313-326.

Soe Pa Pa Kyaw and Soe Htun. 2009. Studies on the morphology and distribution of *Dictyota hauckiana* Nizamuddn (Dictyotales, Phaeophyta) from Myanmar. Universities Research Journal (Myanmar) 2(3):305-322.

Soe Soe Aye. 2009. Marine shells recorded from Thandar Island in the Andaman Sea. Journal of the Myanmar Academy of Arts and Science 8(4):147-160.

Soe Soe Than. 2012. Distribution and habitat utilization of some bird species in Myeik Township, Tanintharyi Region. Master of Science. Myeik University.

Soe Than. 2006. Seasonal and spatial variation of meiofauna in the intertidal zone of Chaungtha beach. Doctor of Philosophy. University of Yangon.

Soe Thant. 1979. The comparative osteology of some of the Burmese flat fishes (Pleuronectiformes). Master of Science. Arts and Science University, Rangoon.

Soe Thant and Maung Maung Lwin. 2011. Distribution of Hawksbill turtles (*Eretmochelys imbricata*) in Longlonebok Island and its adjacent area in Myanmar. *In* Proceedings of the 7th International Symposium on SEASTAR2000 and Asian Biologging Science (The 11th SEASTAR2000 Workshop), March 8-9, 2011. Bangkok, Thailand. 9-14.

Soe Thu. 1980. Taxonomy and distribution of Burmese marine gastropods (Part 1). Master of Science. Arts and Science University, Rangoon.

Soe Tint Aung. 2010. Studies on the corals (Family: Acroporidae) of Shwe Thaung Yan coastal region. Master of Science.

Soe Tun. 1984. Studies on the genus *Sargassum* (Phaeophyta, Fucales) of Burma. Master of Science.

Southeast Asian Fisheries Development Center. 2013. Report of the forty-fifth meeting on the council of the Southeast Asian Fisheries Development Center. Cebu, Philippines, 1-5 April, 2013. Report. 232 pp.

Sreeja, V., A. Bijukumar, and M.D. Norma. 2012. First report of *Amphioctopus neglectus* (Nateewathana & Norman, 1999) and *A. rex* (Nateewathana & Norman, 1999) (Mollusca: Cephalopoda) from the Indian coast. Molluscan Research 32(1):43-49.

Stevens, J.D., R. Bonfil, N.K. Dulvy, and P.A. Walker. 2000. The effects of fishing on sharks, rays, and chimaeras (chondrichthyans), and the implications for marine ecosystems. ICES Journal of Marine Science: Journal du Conseil 57(3):476-494.

Stevenson, C., L.S. Katz, F. Micheli, B. Block, K.W. Heiman, C. Perle, K. Weng, R. Dunbar, and J. Witting. 2007. High apex predator biomass on remote Pacific islands. Coral Reefs 26(1):47-51.

Su Su Htwe. 2010. Studies on red sea weeds (Phylum: Rhodophyta) of in and near Magyi coastal area Master of Science.

Su Su Khin. 1992. The structure of anatomy of *Sepia pharaonis* Ehernberg, 1831 (Mollusca: Cephalopoda). Master of Science. University of Yangon.

Swe Swe Myint. 2003. Correlation between length and age of *Lates calcarifer* (Bloch, 1790) based on otolith microstructure. Master of Research. University of Yangon.

Swe Swe Myint. 2007. Occurrence of some diseases on Tiger shrimp *Penaeus monodon* Snaargone, 1798. Doctor of Philosophy. University of Yangon.

Tay Zar Tun. 2010. Study on the mangrove (Family: Avicenniancea)of Magyi coastal area. Master of Science. Pathein University.

Than Htaike. 1999. Growth of Jumbo Tiger shrimp *Penaeus monodon* in relation to various salinity concentrations. Master of Science. University of Yangon.

Than Than Naing. 2000. The anatomy and histology of *Belone strongylurus*. Master of Science. University of Yangon.

Than Than Soe. 2012. Biology of prawn and shrimp population in the Thanlwin River mouth and adjacent coastal waters. Doctor of Philosophy. University of Mawlamyine.

Thanda Win. 2011. Impacts of human exploitation on mangrove ecosystem in Gwa coastal region. Doctor of Philosophy. University of Yangon.

Thandar. 2012. Study on the processing method and determination of the nutritive values of the edible seaweed sheets. Master of Science. Mawlamyine University.

Thandar Soe. 2012. Mangrove algal communities of Chaung-Tha and Magyi coastal area. Master of Science. Pathein University.

Thapanand-Chaidee, T., Myint Pe, and I. Chanrachkij. 2010. Status of marine fisheries resources in Myanmar waters: Estimates from bottom trawl survey. Kasetsart University Fisheries Research Bulletin (Thailand) 34(1):35-48.

Thapanand-Chaidee, T., Myint Pe, S. Promjinda, and I. Chanrachkij. 2008. Preliminary survey on catch composition of demersal fisheries resources in the eastern coast of Myanmar``. Report for SEAFDEC/TD/RES/128. 34 pp.

Thaung Htut. 2011. Species composition and distribution of seagrasses in the Magyi (Shwe Thaung Yan) coastal area. Master of Science. Pathein University.

Theobald, W. 1868. Catalogue of the reptiles of British Birna [*sic*]. Journal of the Linnean Society of London 10:4-67.

Thet Lyar Win. 2012. Study on Pony fish (Family - Leiognathidae) from Myeik waters. Master of Science. Myeik University.

Thet Myat Lwin. 2006. Species diversity and distribution of commercial marine fish species in some parts of coastal area in Myanmar. Doctor of Philosophy. University of Yangon.

Thet Su Mar. 2010. Community structure of Brachyura crab species in mangrove area of Pyindaye Reserved Forest. Doctor of Philosophy. University of Yangon.

Thet Swe. 1987. The anatomy and histology of *Rastrelliger kanagurta* (Cuvier, 1817). Master of Science. University of Rangoon.

Thet Thet Myaing. 2006. Spatial and temporal fluc-

tuation of marine fish species in off-shore fishing ground around Myeik area. Doctor of Philosophy. University of Yangon.

Thi Thi Htaik. 2009. Ecology of mangrove forests in the coastal zone of Mon State with special reference to the Family Sonneratiaceae. Doctor of Philosophy. University of Mawlamyine.

Thi Thi Lay. 1983. Preliminary studies on field and laborator culture of edible oysters at Setse, Mon State, Burma. Master of Science. Moulmein Degree College.

Thi Thi Mar. 1981. Comparative osteology of skulls of some demersal fishes. Master of Science. Arts and Science University, Rangoon.

Thi Thi Mar. 2009. Development of in vitro endotoxin test with local horseshoe crab, *Tachypleus rotundicauda* (Latreille, 1802). Doctor of Philosophy. University of Yangon.

Thida Aung. 2006. Comparison age and development stages of *Polynemus paradiseus* Linnaeus and *Glossogobius giuris* Hamilton. Doctor of Philosophy. University of Yangon.

Thida Khin Khin Htun. 1998. Comparative study on the dentition of some marine and freshwater fishes from Yangon markets. Master of Science. University of Yangon.

Thin Shwe Yee Win. 2010. Studies on the properties alginate extracted *Colpomenia sinuosa* (Mertens Exroth) Derbes & Solier of Setse. Master of Science. Mawlamyine University.

Thin Thin Maw. 2009. Investigation of squid fishing and catch rate based on some fishery depots of Yangon environ. Master of Research. University of Yangon.

Thint Thint Aung. 1994. The anatomy and histology of *Alectis indicus* (Rupell, 1828). Master of Science. University of Yangon.

Thinzar Lwin Lwin. 2011. Study on the length-weight relationship and some population parameters of mud-crab *Scylla olivacea*. Master of Science. Myeik University.

Thiri Tun. 2010. Observation on the prawn fishery of Setse Coast. Master of Science. Mawlamyine University.

Thorbjarnarson, J.B., S.G. Platt, and Saw Tun Khaing. 1999. Ecological reconnaissance of Meinmahla Kyun Wildlife Sanctuary and vicinity, Southern Ayeyarwady Delta, Myanmar. Report for Wildlife Conservation Society, Bronx, New York.

Thorbjarnarson, J.B., S.G. Platt, and Saw Tun Khaing. 2000a. Conservation status of freshwater turtles in Meinmahla Kyun Wildlife Sanctuary and vicinity, Myanmar. Natural History Bulletin of the Siam Society 48(2):185-191.

Thorbjarnarson, J.B., S.G. Platt, and Saw Tun Khaing. 2000b. Sea turtles in Myanmar: Past, and present. Marine Turtle Newsletter 88:10-11.

Thorbjarnarson, J.B., S.G. Platt, Win Ko Ko, Khin Myo Myo, Lay Lay Khaing, Kaylar, and B. Holmstrom. 2006. Crocodiles in Myanmar: Species diversity, historic accounts, and current population status and conservation. Herpetological Natural History 10(1):67-79.

Thu Thu Minn. 2012. Study on the Family Gobiidae from Mon State. Master of Research. Mawlamyine University.

Thu Ya Kyi Zin. 2011. Baseline data on the artisanal fishery of the ThanLwin River mouth areas. Master of Science. University of Mawlamyine.

Tin Myo Aung. 2010. Studies on the corals (Family - Fungiidae and Faviidae) of Shwe Thaung Yan coastar region. Master of Science. Pathein University.

Tin Oo. 1983. The study on the caudal appendages of some marine fishes. Master of Science. Arts and Science University, Rangoon.

Tin Tin Aye. 2004. Correlation between age, growth rate and sex reversal in seabass *Lates calcarifer* (Bloch, 1790) based on otolith, scale microstructure and length parameters. Doctor of Philosophy. University of Yangon.

Tin Tin Win. 1992. Taxonomic studies of some mesopelagic and deepsea fishes off the Taninthayi coast. Master of Science. University of Yangon.

Tin Win. 17-20 April, 2000. Grouper aquaculture in Myanmar. *In* Regional Workshop on Sustainable Seafarming and Grouper Aquaculture. Network of Aquaculture Centres in Asia-Pacific, Bangkok, Thailand. Medan, Indonesia. 109-118.

Tint Swe. 1987. Occurrence and distribution of fish in the mangrove creek at Setse. Master of Science. University of Mawlamyine.

Tint Swe. 2011. Biology and economics of fishery resources caught by stationary bagnets along the coast of Mon State. Doctor of Philosophy. University of Mawlamyine.

Tint Swe and Daw Tin Nu. 2012. Fishery resources surveys by bottom otter trawl of TRV Annawartheikpan cruises during 1989 to 2002. Presentation to Mawlamyine University Department of Marine Science.

Tint Swe, San Tha Tun, and Tint Tun. 2011. Preliminary ichthyological survey at Lampi Island and some adjacent islands, Myeik Archipelago. Myeik University Research Journal 3(1):52-68.

Tint Tun. 1984. Anatomy and histology of *Pinctada margaritifera* (Linnaeus, 1758). Master of Science. Arts and Science University, Rangoon.

Tint Tun. 1989. On the growth of Pearl oyster *Pinctada fucata* (Gould). University of Mawlamyine

Tint Tun. 1998. Myanmar pearling: past, present and future. SPC Pearl Oyster Information Bulletin 12:3-7.

Tint Tun. 2000. A review fo mass mortalities in pearl oysters. SPC Pearl Oyster Information Bulletin 14:17-20.

Tint Tun. 2005. Castnet fisheries in cooperation with Irrawaddy dolphins (Ayeyarwady dolphins) at Hsithe, Myitkangyi and Myayzun Villages, Mandalay Division, in Myanmar. Report for Wildlife Conservation Society. 44 pp.

Tint Tun. 2006. Preliminary assessment of cetacean catches in coastal waters near Myeik and Dawei in southeastern Myanmar. Report for The Myanmar Department of Fisheries, the Wildlife Conservation Society, and the Convention on Migratory Species. 31 pp.

Tint Tun. 2010. Dugong feeding trails of Lampi Marine National Park. Report for Istituto Oikos and Biodiversity and Nature Conservation Association (BANCA). 22 pp.

Tint Tun. 2011. Dugong information from Lampi Marine National Park in southern Myanmar. *In* Proceedings of the 7th International Symposium on SEASTAR2000 and Asian Bio-logging Science (The 11th SEASTAR2000 Workshop), March 8-9, 2011. Bangkok, Thailand. 15-21.

Tint Tun and Aung Myint Oo. 2008. A Socio-Economic Survey at Some Islands Adjacent to the Lampi Marine National Park. Report for Biodiversity and Nature Conservation Association (BANCA) and Europe Conservation Switzerland (ECoSwiss). 18 pp.

Tint Tun and B. Bendell. 2010. Preliminary observations on the seagrasses of Lampi and neighbouring islands of The Myeik Archipelago, Myanmar. *In* 6th International Symposium on SEASTAR2000 and Asian Bio-logging Science (The 10th SEASTAR2000 Workshop), February 23-25, 2010. Phuket, Thailand. 85-91.

Tint Tun and A.D. Ilagankoon. 2008. Assessment of dugong (*Dugong dugon*) occurrence, distribution and threats in the north-western coastal waters of Rakhine State, Myanmar. Report for Society for Marine Mammalogy. 14 pp.

Tint Tun and A.D. Ilangakoon. 2006. Capacity building and preliminary assessment on dugong (*Dugong dugon*) occurrence off the Rakhine coast of Myanmar. Report for Society for Marine Mammalogy. 23 pp.

Tint Tun, A.D. Ilangakoon, and Maung Maung Thein Pe. 2009. Dugong in Man Aung water, Myanmar. *In* 5th International Symposium on SEASTAR2000 and Asian Bio-logging Science (The 9th SEASTAR2000 Workshop), March 5-6, 2009. Bangkok, Thailand. 63-66.

Tint Tun and Thi Thi Lay. 1989. Growth of rock oyster spats fed with two microalgae. Page 4. University of Mawlamyine. 4.

Tint Tun, Tint Swe, and Nang Mya Han. 1991. Report on some aspects of fisheries biology of Bombay duck (*Harpadon nehereus*). University of Mawlamyine

Tint Tun, Tint Swe, and San Tha Tun. 2008. Preliminary Icthyological survey at Lampi and adjacent islands. Report for Biodiversity and Nature Conservation Association (BANCA) and Europe Conservation Switzerland (ECoSwiss).

Toe Nanda Tin. 2009. Sustainable development of grouper hatchery and culture in Myanmar. Doctor of Philosophy. University of Yangon.

Toe Toe Aung. 1987. Studies on the extraction and properties of agar-agar from *Gracilaria* species and the fractionation of the agar-agar into agarose. Master of Science. Moulmein Degree College.

Toe Toe Aung, Y. Mochida, and Maung Maung

Than. 2013. Prediction of recovery pathways of cyclone-disturbed mangroves in the mega delta of Myanmar. Forest Ecology and Management 293:103-113.

Tsamenyi, M. 2011. A review of Myanmar fisheries legislation with particular reference to freshwater fisheries legislation. Report for Environmentally Sustainable Food Security Programme. 72 pp.

Tun Tun Zaw. 2012. Study on sedimentation of the Thanlywin River mouth and nearby shorelines. Doctor of Philosophy. University of Mawlamyine.

UNEP-WCMC, WorldFish Centre, WRI, and TNC. 2010. Global distribution of warm-water coral reefs, compiled from multiple sources, including the Millennium Coral Reef Mapping Project. UNEP World Conservation Monitoring Centre, Cambridge (UK).

UNESCO. 1985. Strengthening of marine science training and research at Moulmein College. Report. 56 pp.

United Nations Environment Programme. 2007. The Memorandum of Understanding on the Conservation and Management of Dugongs and their Habitats throughout their Range. 4 pp.

United Nations Office for Ocean Affairs and the Law of the Sea. 1989. The Law of the Sea; Baselines: National Legislation with Illustrative Maps. Report. 390 pp.

Veron, J.E.N. 2000. Corals of the World. Australian Institute of Marine Science, Townsville, Australia. 1382 pp.

Veron, J.E.N., L.M. Devantier, E. Turak, A.L. Green, S. Kininmonth, M. Stafford-Smith, and N. Peterson. 2009. Delineating the coral triangle. Galaxea, Journal of Coral Reef Studies 11(2):91-100.

Wabnitz, C.C., S. Andréfouët, D. Torres-Pulliza, F.E. Müller-Karger, and P.A. Kramer. 2008. Regional-scale seagrass habitat mapping in the Wider Caribbean region using Landsat sensors: Applications to conservation and ecology. Remote Sensing of Environment 112:3455-3467.

Wah Wah Khaing, Khin Su Sun Htay, and Ngwe Sandar. 2013. Study of some mangrove plants in Myeik coastal line. Report for Myeik Univeristiy. 21 pp.

Wai Wai Kan Oo. 1982. A study on the general anatomy of *Sepia esculenta* Hoyle, 1885. Master of Science. Arts and Science University, Rangoon.

Wai Zar Phyo. 2012. Study on the relationship between physical parameters of Surimi and composition of fish species used. Master of Science. Myeik University.

War War Shwe. 2010. The morphology and distribution of *Acanthophora spicifera* (M. Vahl) Rgesen (Ceramiales, Rhodophyta) from Myanmar. Master of Science. University of Mawlamyine.

War War Soe. 2008. Study on the status of coral communities in Myeik Archipelago with special reference to Thayawthadangyi-Kyun. Master of Research. Myeik University.

War War Soe and Htay Aung. 2009. Hard corals composition and diversity on coral reefs surrounding the Thayawthadangyi-Kyun in the north of Myeik Archipelago. Journal of the Myanmar Academy of Arts and Science 7(5):415-448.

Wells, D.R. 2007. The Birds of the Thai-Malay Peninsula. Christopher Helm, London. 704 pp.

Wildlife Conservation Society. 2013. Myanmar Biodiversity Conservation Investment Vision. Report. 68 pp.

Wildlife Conservation Society. Web page. Myanmar Biodiversity. http://www.myanmarbiodiversity.org/coordies_sites.php

Win Htin. 1989. Current status and utilization of seaweed culture in Myanmar. *In* Regional Workshop on the Culture & Utilization of Seaweeds. Qingdao, China.

Win Win Si. 2011. Seasonal occurrence and economic importance of Spiny lobsters in Myeik environs, Tanintharyi Region. Doctor of Philosophy. University of Yangon.

Win Yadana Htay. 2010. Studies on some seagrasses (Family: Hydrocharitaceae and Cymodoceaceae) of in and near MaGyi coastal area. Master of Science. Pathein University.

Wint Thuzar Nwe. 2010. Studies on the properties of carrageenan extracted from *Catenella nipae* Zanardini of Setse. Master of Science. Mawlamyine University.

Wint Yee Paing. 2010. Study on the mangrove (Family Rhizophoraceae) of Magyi coastal area. Master of Science. Pathein University.

Work, T.M., G.S. Aeby, and J.E. Maragos. 2008. Phase Shift from a Coral to a Corallimorph-Dominated Reef Associated with a Shipwreck on Palmyra Atoll. PLoS ONE 3(8):e2989.

World Register of Marine Species. Web page. World Register of Marine Species. http://www.marinespecies.org/

Yee Yee Htwe. 2009. Systematic and ecological aspects of echinoderms in the environs of Maungmagan seashore with reference to sea cucumber species. Doctor of Philosophy. University of Yangon.

Yin Yin Htay. 2008. Studies on the genus *Ligora* (Nemaliales, Rhodophyta) of Myanmar. Master of Research. University of Mawlamyine.

Yin Yin Htay and Soe Htun. 2009. Systematics of *Izziella orientalis* (J. Agardh) Huisman & Schils (Liagoracea, Nemaliates) from Myanmar. Mawlamyine Universities Research Journal 1(1):87-95.

Yin Yin Htay and Soe Htun. 2010. Morphology and distribution of genus *Liagora* Lamouroux (Nemaliales, Rhodophyta) from Myanmar. Universities Research Journal (Myanmar) 2(1):134-146.

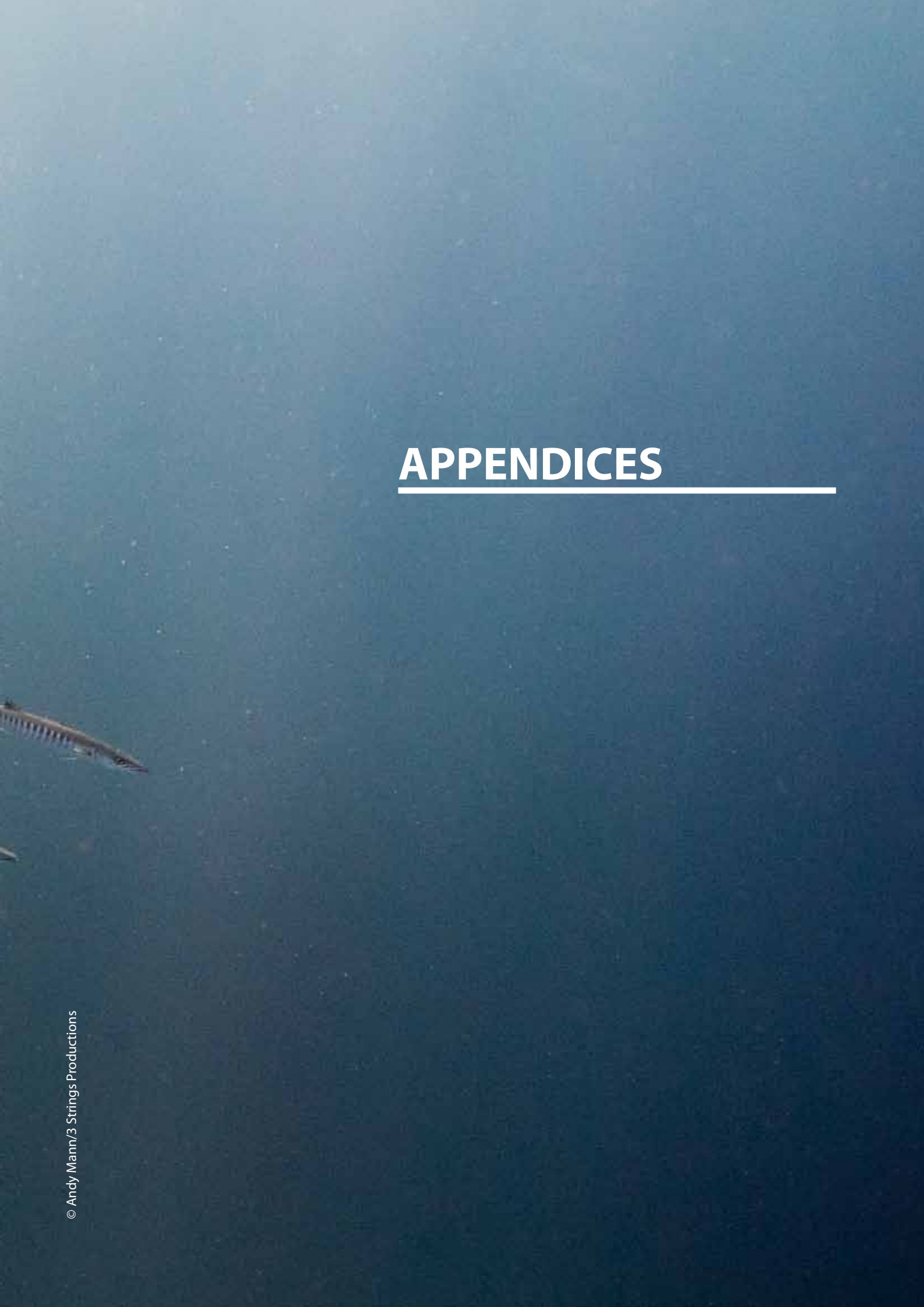
Zarni Ko Ko. 2012. Study on the hard corals (Family - Acroporidae) common in Thayawthadangyikyun and adjacent islands of Myeik Archipelago. Master of Science. Myeik University.

Zaw Lunn. 1988. Seasonal variation of the major nutrients in the coastal waters off Setse, Gulf of Martabon, Mon State. Master of Science. University of Moulmein.

Zaw Zaw Aung. 2012. The fishery status of pomfret (*Pampus argenteus*) in coastal areas of Mon State. Master of Science. Mawlamyine University.

Zöckler, C., E.E. Syroechkovskiy Jr., and P.W. Atkinson. 2010. Rapid and continued decline in the Spoon-billed Sandpiper *Eurynorhynchus pygmeus* indicates imminent extinction unless conservation action is taken. Bird Conservation International 20(2):95-111.

APPENDICES



APPENDIX 1. MANGROVES OF MYANMAR (NOT INCLUDING ASSOCIATES)

Scientific Name	Occurrence	IUCN	*Citation(s)	Coastal Region		
				Rakhine	Ayeya.	Tanin.
Acanthus ilicifolis	Confirmed	LC	4, 5, 6, 12, 14, 20	X	X	X
Acanthus volubilis	Confirmed	LC	4, 6, 12	X	X	X
Acrostichum aureum	Confirmed	LC	4, 5, 12, 14	X	X	X
Aegialitis rotundifolia	Confirmed	NT	1, 4, 5, 12, 13, 14	X	X	X
Aegisceras corniculatum	Confirmed	LC	1, 3, 4, 5, 12, 14	X	X	X
Avicennia alba	Confirmed	LC	1, 3, 4, 5, 12, 13, 14, 17	X	X	X
Avicennia lanata	Probable	VU	8			X
Avicennia marina	Confirmed	LC	1, 3, 4, 6, 12, 13, 14, 16, 17	X	X	X
Avicennia officinalis	Confirmed	LC	1, 3, 4, 5, 12, 13, 13, 14, 16, 17,19, 20	X	X	X
Brownlowia tersa	Confirmed	NT	1, 3, 4, 14	X	X	X
Bruguiera cylindrica	Confirmed	LC	4, 5, 14, 21	X		X
Bruguiera gymnorhiza	Confirmed	LC	3, 4, 5, 12, 13, 14, 21	X	X	X
Bruguiera parviflora	Confirmed	LC	4, 5, 12, 14, 19	X	X	X
Bruguiera sexangula	Confirmed	LC	3, 4, 6, 12, 19, 20	X	X	X
Ceriops decandra	Confirmed	NT	3, 4, 5, 12, 13, 14,20, 21	X	X	X
Ceriops tagal	Confirmed	LC	4, 5, 12, 14, 20, 21	X	X	X
Derris indica	Confirmed		4, 12	X	X	
Derris scandens	Confirmed	LC	4, 12, 14	X	X	X
Derris trifoliata	Confirmed		14			X
Dolichandrone spathacea	Confirmed	LC	14			X
Excoecaria agallocha	Confirmed	LC	1, 3, 4, 5, 12, 14, 19	X	X	X
Heritiera fomes	Confirmed	EN	3, 4, 12, 17	X	X	X
Heritiera littoralis	Confirmed	LC	1, 6, 13, 14			X
Hibiscus tiliaceus	Confirmed		3, 4, 12, 14, 20	X	X	X
Kandelia candel	Confirmed	LC	3, 4, 12	X	X	X
Lumnitzera littorea	Confirmed	LC	6, 14			X

Lumnitzera racemosa	Confirmed	LC	6			X
Nypa fruticans	Confirmed	LC	1, 3, 4, 10, 12, 18	X	X	X
Pemphis acidula	Confirmed	LC	12			X
Phoenix paludosa	Confirmed	NT	1, 3, 4, 10	X	X	X
Rhizophora apiculata	Confirmed	LC	3, 4, 6, 8, 10, 12, 13, 15, 17, 19	X	X	X
Rhizophora mucronata	Confirmed	LC	1, 4, 8, 10, 12	X	X	X
Rhizophora stylosa	Confirmed	LC	6			X
Sesuvium portulacastrum	Possible		1, 12Y			X
Sonneratia alba	Confirmed	LC	4, 13, 18	X		X
Sonneratia apetala	Confirmed	LC	3, 4, 10	X	X	X
Sonneratia caseolaris	Confirmed	LC	3, 4, 9, 10, 15, 16, 17, 18	X	X	X
Sonneratia griffithii	Confirmed	CE	1, 2, 3, 10, 12	X	X	X
Xylocarpus granatum	Confirmed	LC	1, 3, 4, 12	X	X	X
Xylocarpus mekongensis [recorded as *Xylocarpus gangeticus*]	Confirmed	LC	1, 10	X	X	
Xylocarpus moluccensis	Confirmed	LC	1, 4, 10, 18	X	X	X

***Citations**			
1	Aye Aye Mon, 2012	12	Nay Win Oo, 2004
2	Cho Meol Aung, 2010	13	Nyo Nyo San, 2011
3	Forestry Department of Myanmar & Japan International Cooperation Agency, 2005	14	San Tha Tun et al., 2008
4	Hnin Khaing Aye, 2007	15	San Tha Tun, 2011
5	Kyaw Thura, 2011	16	Tay Zar Tun, 2010
6	Kyaw Thura, pers. comm.	17	Thet Su Mar, 2010
7	Khin Wai Hlaing, 2012	18	Thi Thi Htaik, 2009
8	Khit Latt Dwe, 2010	19	Toe Toe Aung et al., 2013
9	Kyaw Tint et al., 2012a	20	Wah Wah Khaing et al., 2013
10	Myint Sein & Bo Ni, 2009	21	Wint Yee Paing, 2010
11	Nant Nay Chit Latt, 2009		

APPENDIX 2. HERMATYPIC CORALS OF MYANMAR

Scientific Name	Occurrence	*Citation(s)	Coastal Region		
			Rakhine	Ayeya.	Tanin.
Family Acroporidae					
Acropora abrotanoides [also recorded as *A. irregularis*]	Confirmed	2, 6, 9			X
Acropora aculeus	Confirmed	2, 6, 9			X
Acropora acuminata	Confirmed	2, 5, 6, 9			X
Acropora appressa	Possible	5			X
Acropora aspera	Confirmed	1, 2, 3, 5, 6, 9	X		X
Acropora austera	Confirmed	2, 5, 6, 8, 9	X		X
Acropora bifurcata	Possible	5			X
Acropora carduus	Possible	6, 9			
Acropora cerealis	Confirmed	2, 5, 6, 9			X
Acropora clathrata	Probable	5, 6, 9			X
Acropora cytherea [also recorded as *A. efflorescens*]	Confirmed	2, 5, 6, 9			X
Acropora dendrum	Confirmed	2, 6, 8, 9	X		X
Acropora digitifera	Confirmed	1, 2, 5, 9	X		X
Acropora divaricata [also recorded as *A. stoddarti*]	Confirmed	2, 5, 6, 9			X
Acropora donei	Possible	6, 9			
Acropora echinata	Probable	5, 6, 9			X
Acropora florida	Confirmed	2, 6, 9			X
Acropora gemmifera	Confirmed	2, 5, 6, 9			X
Acropora granulosa	Probable	5			X
Acropora grandis	Possible	6, 9, 12			
Acropora horrida	Probable	5, 6, 9			X
Acropora humilis [also recorded as *A. ocellata*]	Confirmed	2, 4, 5, 6, 9			X
Acropora hyacinthus	Confirmed	2, 3, 5, 6, 9			X
Acropora inermis	Confirmed	5			X
Acropora intermedia	Probable	5			X
Acropora kosurini	Confirmed	5			X
Acropora latistella	Confirmed	2, 5, 6, 9			X
Acropora listeri	Confirmed	2, 6, 9			X
Acropora longicyathus	Possible	6, 9			
Acropora loripes	Confirmed	2, 5, 6, 9			X
Acropora lutkeni	Probable	5			X
Acropora macrostoma	Probable	5			X
Acropora microphthalma [also recorded as *A. inermis*]	Confirmed	2, 5, 6, 9			X
Acropora millepora	Confirmed	2, 6, 9			X
Acropora monticulosa	Possible	6, 9			
Acropora multiacuta	Confirmed	2, 6, 9			X

Acropora muricata [recorded as *A. formosa*]	Confirmed	2, 5, 6, 9		X
Acropora nana	Probable	5		X
Acropora nasuta	Confirmed	2, 5, 6, 9		X
Acropora palmerae	Confirmed	2, 6, 9		X
Acropora pharaonis	Possible	1, 4, 6		X
Acropora pulchra	Possible	6, 9		
Acropora rambleri	Possible	6, 9		
Acropora retusa	Possible	5		X
Acropora robusta [also recorded as *A. nobilis and A. pinguis*]	Confirmed	2, 3, 5, 6, 9		X
Acropora roseni	Possible	5		X
Acropora rudis	Confirmed	2, 5, 6, 9		X
Acropora samoensis [also recorded as A. wallacea]	Confirmed	2, 5, 6, 8, 9, 11	X	X
Acropora schmitti [taxonomy uncertain]	Confirmed	2, 9		X
Acropora secale	Confirmed	2, 3, 5, 6, 9		X
Acropora selago	Confirmed	2, 5, 6, 9		X
Acropora spicifera	Probable	5		X
Acropora subglabra	Possible	6, 9		
Acropora subulata	Confirmed	2, 5, 6, 9		X
Acropora tenuis [also recorded as A. macrostoma]	Confirmed	2, 5, 6, 9		X
Acropora valenciennesi	Confirmed	2, 3, 6, 9		X
Acropora valida [also recorded as A. variabilis]	Confirmed	2, 5, 6, 9		X
Acropora vaughani	Confirmed	2, 6, 9		X
Acropora verweyi	Confirmed	2, 6, 9		X
Acropora yongei	Probable	3, 6		X
Astreopora expansa	Probable	5, 6, 9		X
Astreopora gracilis	Probable	5		X
Astreopora incrustans	Possible	5		X
Astreopora listeri	Confirmed	2, 5, 6, 9		X
Astreopora myriophthalma	Confirmed	2, 5, 6, 9, 11		X
Astreopora ocellata	Probable	1, 4, 5, 6, 10	X	X
Isopora brueggemanni [recorded as Acropora brueggemanni]	Probable	1, 2, 4, 6	X	X
Isopora cuneata [recorded as Acropora cuneata]	Confirmed	2, 6, 9		X
Isopora palifera [recorded as *Acropora palifera*]	Confirmed	2, 5, 6, 9		X
Montipora aequituberculata	Confirmed	2, 5, 6, 9, 12		X
Montipora angulata	Confirmed	2, 6, 9		X
Montipora calcarea	Possible	5		X
Montipora confusa	Probable	5		X
Montipora cryptus	Possible	5		X
Montipora crassituberculata	Confirmed	1, 2, 6, 9, 10	X	X

Montipora danae [recorded as *Porities convexa*]	Probable	1, 4, 6			X
Montipora digitata	Confirmed	2, 5, 6, 9			X
Montipora efflorescens	Confirmed	1, 2, 4, 5, 6, 9			X
Montipora effusa	Possible	5			X
Montipora floweri	Probable	5			X
Montipora foliosa	Confirmed	2, 6, 9			X
Montipora foveolata	Probable	5, 6, 9			X
Montipora hispida	Confirmed	1, 2, 5, 6, 9, 10			X
Montipora informis	Confirmed	1, 4, 5, 6, 9			X
Montipora mollis	Confirmed	2, 6, 9			X
Montipora monasteriata	Probable	5, 6, 9, 12			X
Montipora nodosa	Probable	5			X
Montipora peltiformis	Confirmed	2, 6, 9			X
Montipora spongodes	Confirmed	2, 5, 6, 9			X
Montipora spumosa	Confirmed	2, 6, 9			X
Montipora stellata [recorded as *M. solanderi* and *M. striata*]	Confirmed	1, 4, 6	X		X
Montipora stilosa	Possible	5			X
Montipora tuberculosa	Confirmed	2, 5, 6, 9			X
Montipora turgescens	Confirmed	2, 6, 9			X
Montipora undata	Confirmed	2, 5, 6, 9			X
Montipora venosa	Confirmed	2, 6, 9			X
Montipora verrucosa	Confirmed	2, 5, 6, 9			X
Family Agariciidae					
Coeloseris mayeri	Confirmed	1, 5, 6, 9, 10	X		X
Gardineroseris planulata	Confirmed	1, 2, 5, 6, 9, 10			X
Leptoseris amitoriensis	Possible	5			X
Leptoseris explanata	Possible	6, 9, 12			
Leptoseris foliosa	Probable	5, 6, 9			X
Leptoseris gardineri	Possible	6, 9			
Leptoseris glabra	Possible	5			X
Leptoseris incrustans	Probable	5			X
Leptoseris hawaiiensis	Possible	6, 9			
Leptoseris mycetoseroides	Confirmed	2, 5, 6, 9			X
Leptoseris papyracea	Possible	6, 9			
Leptoseris scabra	Probable	5, 6, 9			X
Leptoseris solida	Possible	5			X
Pachyseris rugosa	Confirmed	2, 5, 6, 9, 10			X
Pachyseris speciosa	Confirmed	1, 2, 5, 6, 9, 12	X		X
Pavona cactus	Confirmed	2, 5, 6, 9, 12			X
Pavona clavus	Confirmed	2, 5, 6, 9			X
Pavona decussata	Confirmed	1, 2, 3, 5, 6, 9, 10		X	X
Pavona duerdeni	Confirmed	2, 5, 6, 9			X
Pavona explanulata	Confirmed	2, 5, 6, 9			X

Pavona frondifera	Probable	1, 2, 4, 6		X
Pavona maldivensis	Confirmed	1, 2, 5, 6, 9	X	X
Pavona minuta	Confirmed	2, 6, 9		X
Pavona varians	Confirmed	2, 5, 6, 9		X
Pavona venosa	Confirmed	1, 2, 5, 6, 9, 10		X
Family Astrocoeniidae				
Madracis kirbyi	Confirmed	1, 2, 5, 6, 9, 10	X	X
Palauastrea ramosa	Confirmed	1, 2, 6, 9, 10		X
Stylocoeniella armata	Probable	1, 4, 5, 6, 10		X
Stylocoeniella guentheri	Confirmed	2, 5, 6, 9		X
Family Coscinaraeidae				
Anomastraea irregularis	Unlikely	5		X
Coscinaraea columna	Confirmed	2, 5, 6, 9, 12		X
Coscinaraea crassa	Possible	5		X
Coscinaraea exesa	Probable	5		X
Coscinaraea monile	Confirmed	1, 2, 5, 6, 9		X
Coscinaraea wellsi	Confirmed	5		X
Family Dendrophyllidae				
Heteropsammia cochlea	Confirmed	2, 6, 9		X
Tubastraea micranthus [recorded as *T. micrantha*]	Confirmed	5		X
Turbinaria frondens	Confirmed	1, 2, 5, 6, 9, 12	X	X
Turbinaria irregularis	Possible	5		X
Turbinaria mesenterina	Confirmed	2, 5, 6, 9, 12		X
Turbinaria peltata	Confirmed	1, 2, 5, 6, 9		X
Turbinaria reniformis	Confirmed	2, 6, 9		X
Turbinaria stellulata	Confirmed	2, 5, 6, 9		X
Family Euphyllidae				
Euphyllia ancora	Probable	5, 6, 9, 12		X
Euphyllia glabrescens	Confirmed	2, 4, 5, 6, 9		X
Physogyra lichtensteini	Confirmed	2, 5, 6, 9, 12		X
Plerogyra sinuosa	Confirmed	2, 4, 5, 6, 9, 12		X
Family Faviidae				
Blastomussa loyae [recorded as *Parasimplastrea sheppardi*]	Possible	5		X
Blastomussa merleti	Possible	5		X
Caulastraea connata	Unlikely	5		X
Coelastrea aspera [recorded as *Goniastrea aspera*]	Confirmed	2, 5, 6, 9		X
Cyphastrea chalcidicum	Confirmed	2, 5, 6, 9, 12		X
Cyphastrea microphthalma	Confirmed	2, 5, 6, 9, 12		X
Cyphastrea serailia	Confirmed	1, 2, 5, 6, 9		X
Diploastrea heliopora	Confirmed	2, 5, 9, 12		X
Dipsastraea danai [recorded as Favia danae]	Confirmed	5		X
Dipsastraea favus [recorded as *Favia favus*]	Confirmed	1, 2, 5, 6, 9, 11	X	X

Dipsastraea helianthoides [recorded as *Favia helianthoides*]	Confirmed	2, 5, 6, 9, 11			X
Dipsastraea lacuna [recorded as *Favia lacuna*]	Confirmed	2, 6, 9, 11			X
Dipsastraea laxa [recorded as *Favia laxa*]	Confirmed	1, 2, 6, 9,11	X		X
Dipsastraea lizardensis [recorded as *Favia lizardensis*]	Confirmed	2, 5, 6, 9, 12			X
Dipsastraea maritima [recorded as *Favia maritima*]	Confirmed	2, 5, 6, 12			X
Dipsastraea matthaiil [recorded as *Favia matthaii*]	Confirmed	2, 5, 9, 12			X
Dipsastraea maxima [recorded as *Favia maxima*]	Confirmed	2, 5, 6, 9, 12			X
Dipsastraea pallida [recorded as *Favia pallida*]	Confirmed	2, 5, 6, 9, 12			X
Dipsastraea rosaria [recorded as *Favia rosaria*]	Possible	5			X
Dipsastraea rotumana [recorded as *Favia rotumana*]	Confirmed	2, 5, 6, 9			X
Dipsastraea rotundata [recorded *as Favia rotundata]*	Confirmed	2, 6, 9			X
Dipsastraea speciosa [recorded as *Favia speciosa*]	Confirmed	1, 2, 4, 5, 6, 7, 9, 12		X	X
Dipsastraea stelligera [recorded as *Favia stelligera*]	Confirmed	2, 5, 6, 9, 10			X
Dipsastraea truncata [recorded as *Favia truncatus*]	Possible	5			X
Dipsastraea veroni [recorded as *Favia veroni*]	Probable	5			X
Dipsastraea vietnamensis [recorded as *Favia vietnamensis*]	Probable	5			X
Dipsastrea amicorum [recorded as *Barabattoia amicorum*]	Confirmed	2, 5, 6, 9			X
Echinopora gemmacea	Confirmed	1, 5, 6, 9	X		X
Echinopora horrida	Confirmed	2, 6, 9			X
Echinopora lamellosa	Confirmed	2, 5, 6, 7, 9, 10, 12			X
Echinopora pacificus	Probable	5			X
Echinopora taylorae [recorded as *Echinophyllia taylorae*]	Possible	5			X
Favites abdita	Confirmed	1, 2, 4, 5, 6, 9, 10, 12	X		X
Favites acuticollis	Probable	5			X
Favites chinensis	Probable	5			X
Favites complanata	Confirmed	2, 5, 6, 9, 12			X
Favites flexuosa	Possible	6, 9			
Favites halicora	Confirmed	2, 5, 6, 9, 12			X
Favites melicerum [recorded as *F. bestae*]	Confirmed	5			X
Favites pentagona	Confirmed	2, 5, 6, 9, 12			X

Favites russelli	Confirmed	2, 5, 6, 9		X
Favites spinosa	Possible	5		X
Favites vasta	Possible	5		X
Goniastrea edwardsi	Confirmed	2, 5, 6, 9		X
Goniastrea minuta	Probable	5		X
Goniastrea palauensis	Confirmed	2, 5, 6, 9		X
Goniastrea pectinata	Confirmed	1, 2, 4, 5, 6, 7, 9	X	X
Goniastrea retiformis	Confirmed	1, 2, 3, 4, 5, 6, 9, 12	X	X
Leptastrea aequalis	Confirmed	2, 5, 6, 9		X
Leptastrea bewickensis	Possible	2, 6, 9		X
Leptoria irregularis	Possible	5		X
Leptastrea pruinosa	Confirmed	2, 5, 6, 9		X
Leptastrea purpurea	Confirmed	2, 5, 6, 9		X
Leptastrea transversa	Confirmed	2, 5, 6, 9, 10		X
Leptoria phrygia	Confirmed	2, 5, 6, 9, 10		X
Oulastrea crispata	Confirmed	2, 6, 9, 10		X
Oulophyllia bennettae	Confirmed	2, 6, 9, 12		X
Oulophyllia crispa	Confirmed	2, 5, 6, 9		X
Oulophyllia levis	Possible	5		X
Paragoniastrea australensis [recorded as *Goniastrea australensis*]	Possible	5		X
Paramontastraea salebrosa [recorded as *Montastrea salebrosa*]	Possible	5		X
Phymastrea annuligera or *Astrea annuligera* [taxonomy disputed, recorded as *Montastrea annuligera*]	Probable	5		X
Phymastrea curta or *Astrea curta* [taxonomy disputed, recorded as *Montastraea curta*]	Confirmed	2, 5, 6, 9, 11		X
Phymastrea magnistellata or *Favites magnistellata* [taxonomy disputed, recorded as *Montastraea magnistellata*]	Confirmed	2, 5, 6, 9, 11		X
Phymastrea valenciennesi or *Favites valenciennesi* [taxonomy disputed, recorded as *Montastraea valenciennesi*]	Confirmed	2, 5, 6, 9, 10, 11		X
Platygyra acuta	Probable	5		X
Platygyra carnosa [recorded as *P. carnosus*]	Possible	5		X
Platygyra daedalea	Confirmed	2, 5, 6, 9		X
Platygyra lamellina	Confirmed	1, 2, 4, 5, 6, 7, 9	X	X
Platygyra pini	Confirmed	2, 5, 6, 9, 12		X
Platygyra ryukyuensis	Probable	5		X
Platygyra sinensis	Confirmed	2, 5, 6, 9, 12		X
Platygyra verweyi	Confirmed	2, 5, 6, 9, 12		X
Platygyra yaeyamaensis	Unlikely	5		X
Plesiastrea versipora	Confirmed	2, 5, 6, 9		X

Family Fungiidae					
Ctenactis crassa	Confirmed	2, 6, 9			X
Ctenactis echinata [also recorded as *Fungia echinata]*	Confirmed	1, 2, 5, 6, 7, 9, 12	X		X
Cycloseris costulata	Probable	5, 6, 9			X
Cycloseris cyclolites	Possible	9, 12			
Cycloseris distorta [recorded as *Diaseris distorta]*	Possible	6, 9			
Cycloseris explanulata [recorded as *Psammocora explanulata*]	Probable	5			X
Cycloseris fragilis [recorded as *C. patelliformis* and *Diaseris fragilis*]	Confirmed	2, 5, 6, 9			X
Cycloseris hexagonalis	Possible	6, 9			
Cycloseris mokai [recorded as *Lithophyllon mokai*]	Confirmed	2, 6, 9			X
Cycloseris somervillei	Confirmed	2, 5, 6, 9, 12			X
Cycloseris tenuis [also recorded as *C. erosa*]	Probable	2, 5, 6, 9			X
Cycloseris wellsi [also recorded as *Coscinaraea wellsi*]	Possible	5, 6, 9, 12			X
Danafungia horrida [recorded as *Fungia danai* and *F. horrida*]	Confirmed	2, 5, 6, 9			X
Danafungia scruposa [recorded as Fungia corona and F. scruposa]	Confirmed	2, 5, 6, 9, 11			X
Fungia fungites	Confirmed	1, 2, 4, 5, 6, 9, 10	X		X
Fungia moluccensis	Confirmed	1, 2, 5, 6, 9, 10	X		X
Halomitra pileus	Possible	6, 9			
Heliofungia actiniformis [recorded as *Fungia actinoformis*]	Confirmed	1, 2, 4, 6, 9		X	X
Herpolitha limax [also synonym *H. weberi* recorded]	Confirmed	1, 2, 4, 5, 6, 9, 10, 12	X		X
Lithophyllon concinna [recorded as *Fungia concinna*]	Confirmed	2, 4, 5, 6, 9, 11			X
Lithophyllon repanda [recorded as *Fungia repanda*]	Confirmed	1, 2, 4, 5, 6, 7, 9	X		X
Lithophyllon scabra [recorded as *Fungia scabra*]	Confirmed	1, 2, 5, 6, 9, 10			X
Lithophyllon undulatum [also synonym *L. lobata* recorded]	Confirmed	2, 5, 6, 11, 12			X
Lobactis scutaria [recorded as *Fungia scutaria*]	Confirmed	2, 3, 6, 9			X
Pleuractis granulosa [recorded as *Fungia granulosa*]	Probable	5, 9			
Pleuractis paumotensis [recorded as *Fungia paumotensis*]	Confirmed	1, 2, 5, 6, 9, 10	X		X
Pleuractis seychellensis [recorded as *Fungia seychellensis*]	Possible	5			X
Podabacia crustacea	Probable	4, 5, 6, 9			X
Podabacia lankaensis	Possible	5			X

Polyphyllia novaehiberniae	Probable	5		X
Polyphyllia talpina	Confirmed	1, 2, 4, 5, 6, 9, 10	X	X
Sandalolitha dentata	Probable	5		X
Sandalolitha robusta	Confirmed	5, 6, 9, 10		X
Family Merulinidae				
Hydnophora exesa	Confirmed	1, 2, 4, 5, 6, 7, 9	X	X
Hydnophora microconos	Confirmed	2, 5, 6, 9		X
Hydnophora rigida	Confirmed	1, 2, 4, 5, 6, 7, 9, 10	X	X
Merulina ampliata	Confirmed	1, 2, 5, 6, 9, 10, 12		X
Merulina scabricula	Confirmed	1, 2, 6, 9, 12	X	X
Scapophyllia cylindrica	Confirmed	2, 5, 6, 9, 12		X
Family Mussidae				
Acanthastrea brevis	Possible	5		X
Acanthastrea echinata	Confirmed	1, 2, 5, 6, 9		X
Acanthastrea hemprichi	Possible	5		X
Acanthastrea regularis	Possible	5		X
Acanthastrea rotundoflora	Confirmed	5		X
Acanthastrea subechinata	Possible	5		X
Cynarina lacrymalis	Confirmed	2, 5, 6, 9		X
Homophyllia australis [recorded as *Scolymia australis*]	Unlikely	5		X
Lobophyllia corymbosa	Confirmed	2, 5, 6, 9, 12		X
Lobophyllia flabelliformis	Probable	5		X
Lobophyllia diminuta	Confirmed	2, 5, 6, 9		X
Lobophyllia hataii	Confirmed	2, 5, 6, 9		X
Lobophyllia hemprichii	Confirmed	1, 2, 4, 5, 6, 9	X	X
Lobophyllia pachysepta	Probable	5		X
Lobophyllia robusta	Probable	5		X
Micromussa amakusensis	Possible	5		X
Parascolymia rowleyensis [recorded as *Australomussa rowleyensis*]	Confirmed	2, 5, 6, 9		X
Symphyllia agaricia	Confirmed	2, 5, 6, 9, 12		X
Symphyllia hassi	Possible	2, 6, 9		X
Symphyllia radians	Confirmed	1, 2, 5, 6, 9, 12		X
Symphyllia recta [also recorded as *S. nobilis*]	Confirmed	1, 2, 5, 6, 7, 9, 12		X
Symphyllia valenciennesi	Confirmed	1, 2, 5, 6, 9, 10		X
Family Oculinidae				
Galaxea astreata	Confirmed	1, 2, 6, 9	X	X
Galaxea fascicularis	Confirmed	2, 5, 6, 9, 12		X
Galaxea pauciradiata [recorded as *G. paucisepta*]	Possible	5		X

Family Pectiniidae					
Echinomorpha nishihirai	Unlikely	5			X
Echinophyllia aspera	Confirmed	2, 5, 6, 7, 9	X		X
Echinophyllia echinata	Confirmed	1, 2, 5, 6, 9			X
Echinophyllia echinoporoides	Probable	5			X
Echinophyllia patula	Probable	5, 6, 9			
Mycedium elephantotus	Confirmed	1, 2, 5, 6, 9, 12			X
Mycedium robokaki	Possible	5			X
Oxypora crassispinosa	Probable	5, 6, 9			X
Oxypora lacera	Confirmed	1, 4, 5, 6, 9			X
Pectinia africana	Possible	5			X
Pectinia alcicornis	Confirmed	1, 2, 5, 6, 9			X
Pectinia lactuca	Confirmed	1, 2, 4, 5, 6, 7, 9, 10			X
Pectinia paeonia	Confirmed	2, 5, 6, 9, 12			X
Pectinia teres	Confirmed	2, 6, 9			X
Family Pocilloporidae					
Pocillopora ankeli	Confirmed	2, 6, 9			X
Pocillopora damicornis	Confirmed	1, 2, 4, 5, 6, 7, 9, 10, 12	X	X	X
Pocillopora grandis [recorded as *P. eydouxi*]	Confirmed	1, 5, 6, 9, 10, 12	X		X
Pocillopora indiania	Possible	5			X
Pocillopora ligulata	Possible	5			X
Pocillopora meandrina	Confirmed	1, 6, 9, 10			X
Pocillopora verrucosa [also recorded as *P. danai*]	Confirmed	1, 2, 4, 5, 6, 9, 10	X		X
Pocillopora woodjonesi	Probable	5, 6, 9			X
Pocillopora zelli	Possible	5			X
Seriatopora caliendrum	Confirmed	2, 6, 9			X
Seriatopora hystrix	Confirmed	1, 2, 4, 6, 9, 10	X		X
Seriatopora stellata	Confirmed	2, 6, 9			X
Stylophora pistillata	Confirmed	1, 2, 6, 9, 10, 12			X
Family Poritidae					
Alveopora allingi	Confirmed	2, 6, 9			X
Alveopora catalai	Confirmed	2, 6, 9			X
Alveopora excelsa	Probable	1, 2, 4	X		X
Alveopora spongiosa	Confirmed	2, 6, 9			X
Alveopora tizardi	Probable	5			X
Goniopora albiconus	Possible	5			X
Goniopora burgosi	Confirmed	2, 6, 9			X
Goniopora columna	Confirmed	1, 2, 4, 5, 6, 9, 12	X		X
Goniopora djiboutiensis	Confirmed	2, 5, 6, 9, 12			X
Goniopora fruticosa	Confirmed	1, 4, 6, 9	X		X

Goniopora lobata	Confirmed	1, 2, 4, 5, 6, 9	X		X
Goniopora pandoraensis	Confirmed	2, 6, 9			X
Goniopora pedunculata [recorded as *G. minor*]	Confirmed	2, 5, 6, 9, 12			X
Goniopora pendulus	Possible	5			X
Goniopora planulata	Probable	5, 6, 9			
Goniopora somaliensis	Confirmed	2, 5, 6, 9, 12			X
Goniopora stokesi	Confirmed	2, 5, 6, 9			X
Goniopora stutchburyi	Confirmed	4, 5, 6, 9			X
Goniopora tenella	Possible	6, 9			
Goniopora tenuidens	Confirmed	2, 6, 9			X
Porites annae	Confirmed	2, 5, 6, 9			X
Porites aranetai	Confirmed	2, 6, 9			X
Porites australiensis	Probable	5, 6, 9			
Porites cylindrica	Confirmed	2, 5, 6, 9, 12			X
Porites deformis	Possible	5			X
Porites evermanni	Confirmed	2, 6, 9			X
Porites horizontalata	Possible	5			X
Porites lichen	Probable	5			X
Porites lobata	Confirmed	1, 2, 5, 6, 9, 12	X		X
Porites lutea	Confirmed	1, 2, 4, 5, 6, 9	X	X	X
Porites monticulosa	Probable	5			X
Porites murrayensis	Confirmed	2, 6, 9, 12			X
Porites nigrescens	Confirmed	1, 4, 5, 6, 9, 12			X
Porites profundus	Possible	5			X
Porites rus [also recorded as *P. convexa*]	Probable	1, 5, 6, 9			X
Porites sillimaniani	Possible	5			X
Porites solida	Confirmed	2, 3, 5, 6, 9			X
Porites stephensoni	Confirmed	2, 5, 6, 9, 12			X
Family Siderastreidae					
Psammocora albopicta	Possible	5			X
Psammocora contigua [also recorded *as P. obtusangula*]	Confirmed	1, 2, 4, 5, 6, 9	X		X
Psammocora digitata	Confirmed	1, 2, 5, 6, 9, 10			X
Psammocora verrilli [recorded as *P. nierstraszi*]	Possible	5			X
Psammocora profundacella	Probable	5, 6, 9			
Pseudosiderastrea tayamai	Confirmed	1, 2, 4, 5, 6, 9, 10	X		X
Siderastrea savignyana	Confirmed	2, 5, 6, 9			X
Family Trachyphylliidae					
Trachyphyllia geoffroyi	Confirmed	4, 5, 6, 9			X

***Citations**			
1	Cherry Aung, 2009a	7	San San Win, 1993
2	Cherry Aung, 2009b	8	Soe Tint Aung, 2010

3	Mya Than Tun & Tint Tun, 2002	9	Veron, 2000
4	Myint Pe, 2003	10	War War Soe & Htay Aung, 2009
5	Obura et al., 2014	11	World Register of Marine Species, Web page
6	OBIS, Web page	12	This study

APPENDIX 3. SEAGRASSES OF MYANMAR

Scientific Name	Occurrence	IUCN	*Citation(s)
Cymodocea rotundata	Confirmed	LC	1, 2, 3, 4, 5, 6, 7, 8, 9
Cymodocea serrulata	Confirmed	LC	1, 4, 5, 6, 7, 8, 9, 10
Enhalus acoroides	Confirmed	LC	1, 3, 4, 5, 6, 7, 8
Halodule pinifolia	Confirmed	NT	1, 3, 4, 5, 6, 7, 8, 9, 10
Halodule uninervis	Confirmed	LC	1, 2, 3, 4, 5, 6, 7, 8, 9, 10
Halophila beccarii	Confirmed	LC	1, 4, 5, 6, 7, 8
Halophila decipiens	Confirmed	VU	2, 4, 5, 6, 7, 8, 9, 10
Halophila minor	Possible	LC	1
Halophila ovalis	Confirmed	LC	1, 3, 4, 5, 6, 7, 8, 9, 10
Syringodium isoetifolium	Confirmed	LC	1, 2, 3, 5, 6, 8, 9
Thalassia hemprichii	Confirmed	NT	1, 3, 5, 6, 7, 9

*Citations			
1	Beffasti, 2010	6	Thaung Htut, 2011
2	Htet Lynn Aung, 2012	7	Tint Tun & Bendell, 2010
3	Novak *et al.*, 2009	8	Win Win Si, 2011
4	Soe Htun *et al.*, 2001	9	Soe Htun, 1998
5	Soe Htun *et al.*, 2009b	10	This study

APPENDIX 4. CETACEANS OF MYANMAR

Scientific Name	Common Name	IUCN	CITES	Occurrence	*Citation(s)
Suborder Mysticeti: Baleen whales					
Balaenoptera edeni	Bryde's whale	DD	I	Confirmed	1,7,8,9
Balaenoptera musculus	Blue whale	EN	I	Confirmed	8
Balaenoptera acutorostrata	Common minke whale	LC	I	Probable	4
Balaenoptera physalus	Fin whale	EN	I	Possible	6
Suborder Odontoceti: Toothed whales (including dolphins and porpoises)					
Indopacetus pacificus	Longman's beaked whale	DD	II	Confirmed	4
Neophocaena phocaenoides	Indo-Pacific finless porpoise	VU	I	Confirmed	7,9,10,11,12
Orcaella brevirostris	Irrawaddy dolphin	VU	I	Confirmed	7,8,9,10,11,12
Sousa chinensis	Indo-Pacific humpbacked dolphin	NT	I	Confirmed	7,8,9,10,11,12
Stenella attenuata	Pantropical spotted dolphin	LC	II	Confirmed	5,7,9,10
Stenella longirostris	Spinner dolphin	DD	II	Confirmed	7,8,9,10
Tursiops aduncus	Indo-Pacific bottlenose dolphin	DD	II	Confirmed	7,8,9,10,12
Mesoplodon layardii	Strap-toothed whale	DD	II	Confirmed, anomaly	2
Mesoplodon densirostris	Blainville's beaked whale	DD	II	Probable	3
Delphinus capensis tropicalis	Long-beaked common dolphin	LC	II	Probable	4
Feresa attenuata	Pygmy killer whale	DD	II	Probable	4
Globicephala macrorhynchus	Short-finned pilot whale	DD	II	Probable	4
Grampus griseus	Risso's dolphin	LC	II	Probable	4,5
Kogia breviceps	Pygmy sperm whale	DD	II	Probable	4
Kogia sima	Dwarf sperm whale	DD	II	Probable	4
Lagenodelphis hosei	Fraser's dolphin	LC	II	Probable	4
Orcinus orca	Killer whale	DD	II	Probable	4
Peponocephala electra	Melon-headed whale	LC	II	Probable	4
Physeter macrocephalus	Sperm whale	VU	I	Probable	4
Pseudorca crassidens	False killer whale	DD	II	Probable	4
Stenella coeruleoalba	Striped dolphin	LC	II	Probable	4
Steno bredanensis	Rough-toothed dolphin	LC	II	Probable	4
Tursiops truncatus	Common bottlenose dolphin	LC	II	Possible	4

*Citations			
1	Anderson, 1878	7	Nang Mya Han, 2008
2	Aung Myo Chit *et al.*, 2012	8	Smith *et al.*, 1997
3	IUCN	9	Smith, 2005
4	Jefferson *et al.*, 2008	10	Smith & Mya Than Tun, 2008
5	Leatherwood *et al.*, 1984	11	Smith & Aung Myo Chit, 2011
6	Mason, 1852	12	Tint Tun, 2006

APPENDIX 5. MARINE TURTLES OF MYANMAR

Scientific Name	Common Name	IUCN	CITES	Occurrence	Citation(s)
Caretta caretta	Loggerhead turtle	EN	I	Confirmed	10
Chelonia mydas	Green turtle	EN	I	Confirmed	1, 2, 4, 5, 7, 8, 10
Lepidochelys olivacea	Olive ridley turtle	VU	I	Confirmed	1, 3, 4, 5, 6, 10
Dermochelys coriacea	Leatherback turtle	CR	I	Confirmed but rare	10
Eretmochelys imbricata	Hawksbill turtle	CR	I	Confirmed but rare	1, 2, 9, 10

*Citations			
1	Kay Thi, 2009	6	Maung Maung Lwin, 2007
2	Kay Thi *et al.*, 2011	7	Maung Maung Lwin, 2009b
3	Ko Myint, 2005	8	Maung Maung Lwin, 2009a
4	Ko Myint, 2007	9	Soe Thant & Maung Maung Lwin, 2011
5	Ko Myint, 2009	10	Thorbjarnarson *et al.*, 2000b

APPENDIX 6. FINFISHES OF MYANMAR

Scientific Name	Common Name	Citations
Anchovy		
Coilia dussumieri	Goldspotted grenadier anchovy	Cho Cho Latt, 2010; Hla Hla Htay, 1994; Khine Khine Lin, 1983; Mie Mie Sein, 2006a; Ngu War Hlaing, 2010; Sein Moh Moh Khaing, 2011; Tint Swe, 2011; Tint Swe & Daw Tin Nu, 2012
Coilia ramcarati	Ramcarat grenadier anchovy	Cho Cho Latt, 2010
Setipinna taty	Scaly hairfin anchovy	Cho Cho Latt, 2010; Tint Swe, 2011; Tint Swe & Daw Tin Nu, 2012
Setipinna tenuifilis	Common hairfin anchovy	Cho Cho Latt, 2010
Setipinna wheeleri	Burma hairfin anchovy	Cho Cho Latt, 2010
Stolephorus sp.	Anchovy	Tint Swe & Daw Tin Nu, 2012
Stolephorus indicus	Indian anchovy	This study
Angelfish		
Heniochus acuminatus	Longfin bannerfish	This study
Heniochus monoceros	Masked bannerfish	This study
Pomacanthus annularis	Blue-ringed angelfish	This study
Pomacanthus imperator	Emperor angelfish	This study
Bahaba		
Bahaba taipingensis	Chinese bahaba	Hnin Ei Soe, 2012
Baramundi		
Lates calcarifer	Barramundi; Seabass	Aye Thida, 2003; Hla Hla Win, 2004; Ma Sein Mo Mo Hlaing, 2011; May Win Maw, 2005; Moe Thida Htway, 2003; Phyu Phyu Sin, 1983; Swe Swe Myint, 2003; Tin Tin Aye, 2004
Barb		
Catlocarpio siamensis	Giant barb	Phyu Phyu Sin, 1983
Barracuda		
Sphyraena barracuda	Great barracuda	Tint Swe & Daw Tin Nu, 2012; This study
Sphyraena jello	Pickhandle barracuda	Cho Cho Mar, 1988; Kyaw Kyaw Htay, 2010; Moe Sapai, 1998; This study
Bigeye		
Heteropriacanthus cruentatus [recorded as *Priacanthus boops*]	Glasseye	Tint Swe & Daw Tin Nu, 2012
Priacanthus spp.	Bigeye	Wai Zar Phyo, 2012; This study
Bonefish		
Albula argentea [recorded as *A. neoguinaica]*	Sharpjaw bonefish	Tint Swe *et al.*, 2011
Bream		
Nemipterus spp.	Bream	Cho Cho Mar, 1988; Maw Maw Than, 1991; May Thet Htar Aung, 1983; Mya Saw, 1975; Saw Nanda, 2000; Sein Moh Moh Khaing, 2011; Tin Oo, 1983; Wai Zar Phyo, 2012

Nemipterus furcosus	Fork-tailed threadfin bream	This study
Nemipterus japonicus [also recorded as *Synagris japonicus*]	Japanese threadfin bream	Cho Cho Mar, 1988; Maw Maw Than, 1991; May Thet Htar Aung, 1983; Mya Saw, 1975; Pauly & Aung, 1984; Saw Nanda, 2000; Sein Moh Moh Khaing, 2011; Tin Oo, 1983; Tint Swe & Daw Tin Nu, 2012; This study
Nemipterus peronii [recorded as *N. tolu*]	Notchedfin threadfin bream	Tint Swe & Daw Tin Nu, 2012
Scolopsis bilineatus	Bridled monocle bream	
Scolopsis ciliatus	Whitestreak monocle bream	This study
Butterflyfish		
Chaetodon collare	White collar butterflyfish	This study
Chaetodon decussatus	Indian vagabond butterflyfish	This study
Chaetodon lunula	Racoon butterflyfish	This study
Chaetodon octofasciatus	Eight-banded butterflyfish	This study
Cardinalfish		
Apogon fleurieu	Flower cardinalfish	This study
Cheilodipterus quinquelineatus	Fivelined cardinalfish	This study
Ostorhinchus thermalis	Half-barred cardinal	This study
Catfish		
Arius spp.	Catfish	Cho Cho Mar, 1988; Khin Khin San, 2010; Kyaw Kyaw Htay, 2010; May Win Maw, 2005; Min Thu Aung, 2006; Moe Sapai, 1998; Naung Naung Oo, 2012; Roberts, 2001; Thi Thi Mar, 1981
Arius gagora	Gagora catfish	Khin Khin San, 2010
Arius maculatus	Spotted catfish	Khin Khin San, 2010; Kyaw Kyaw Htay, 2010
Clarias batrachus	Philippine catfish	Thida Khin Khin Htun, 1998
Mystus seenghala	Giant river-catfish	Kyaw Phone Lynn, 1979; Phyu Phyu Sin, 1983
Mystus vittatus	Striped dwarf catfish	Kyaw Phone Lynn, 1979
Nemapteryx nenga [also recorded as *Arius nenga*]	Catfish	Khin Khin San, 2010
Netuma thalassina [also recorded as *Arius thalassinus*]	Giant catfish	Cho Cho Mar, 1988; Khin Khin San, 2010; Min Thu Aung, 2006; Tint Swe & Daw Tin Nu, 2012
Ompok pabo	Pabo catfish	Aye Aye Cho, 1987
Osteogeneiosus militaris	Soldier catfish	Khin Khin San, 2010; Moe Sapai, 1998; Tint Swe & Daw Tin Nu, 2012
Pangasius pangasius	Pangas catfish	Thida Khin Khin Htun, 1998
Plicofollis dussumieri [recorded *as Arius dussumieri*]	Blacktip sea catfish	Khin Khin San, 2010
Plicofollis dussumieri	Blacktip sea catfish	Khin Khin San, 2010
Plotosus canius	Gray eel catfish	Cho Cho Mar, 1988; Khin Khin San, 2010; Moe Sapai, 1998; Thida Khin Khin Htun, 1998

Plotosus lineatus	Striped eel catfish	Khin Khin San, 2010
Sciades sona [recorded as *Arius sona*]	Sona sea catfish	Moe Sapai, 1998
Sciades sona	Sona sea catfish	Moe Sapai, 1998
Chromodoris		
Chromodoris geminus	Twin chromodoris	This study
Clownfish		
Amphipiron clarikii	Clark's anenome fish	This study
Cobia		
Rachycentron canadum	Cobia	Min Thu Aung, 2006; Tint Swe & Daw Tin Nu, 2012; This study
Conger		
Congresox talabon [also recorded as *Muraenesox talabon*]	Yellow pike conger	Moe Sapai, 1998; Saw Nanda, 2000; Thida Khin Khin Htun, 1998; Tint Swe & Daw Tin Nu, 2012
Cornetfish		
Fistualria sp.	Cornetfish	Tint Swe & Daw Tin Nu, 2012
Corsula		
Rhinomugil corsula	Corsula	Khin Maung Cho, 2009; Kyaw Min Naing, 2010
Cowfish		
Ostracion cornutus	Longhorn cowfish	Khin Khin Nwe, 1990
Croaker		
Chrysochir aureus	Reeve's croaker	Aung Aung Aye, 2010; Hnin Ei Soe, 2012; Khine Khine Lin, 1983; Mie Mie Sein, 2006a; Saw Nanda, 2000; Tin Oo, 1983; Tint Swe, 2011; Tint Swe & Daw Tin Nu, 2012
Dendrophysa russlli	Goatee croaker	Aung Aung Aye, 2010
Johinius coitor	Coitor croaker	Aung Aung Aye, 2010
Johnieops sina	Sin croaker	Hnin Ei Soe, 2012
Johnius belangerii	Belanger's croaker	Aung Aung Aye, 2010; Khine Khine Lin, 1983; Mie Mie Sein, 2006a; Seim Moh Moh Hlaing, 2012
Johnius carutta	Karut croaker	Nu Nu Aye, 1984
Johnius elongatus	Spindle croaker	Aung Aung Aye, 2010
Johnius borneensis [recorded as *J. vogleri*]	Sharpnose hammer croaker	Min Thu Aung, 2006
Nibea soldado	Soldier croaker	Hnin Ei Soe, 2012
Otolithes spp.	Croaker	Aung Aung Aye, 2010; Hnin Ei Soe, 2012; Maw Maw Than, 1991; Thu Ya Kyi Zin, 2011; Wai Zar Phyo, 2012
Otolithes ruber	Tigertooth croaker	Aung Aung Aye, 2010; Hnin Ei Soe, 2012; Maw Maw Than, 1991; Tint Swe & Daw Tin Nu, 2012; This study
Otolithoides biauritus	Bronze croaker	Aung Aung Aye, 2010; Hnin Ei Soe, 2012
Otolithoides pama	Pama croaker	Hnin Ei Soe, 2012; Sein Moh Moh Khaing, 2011; Tint Swe & Daw Tin Nu, 2012
Panna microdon	Panna croaker	Hnin Ei Soe, 2012

Pennahia spp.	Croaker	Hnin Ei Soe, 2012; Maw Maw Than, 1991; Thet Thet Myaing, 2006; Tin Oo, 1983; Wai Zar Phyo, 2012
Pennahia macrocephalus	Big-head pennah croaker	Maw Maw Than, 1991
Pennahia anea [recorded as *P. macrophthalmus*]	Bigeye croaker	Hnin Ei Soe, 2012; Thet Thet Myaing, 2006; Tin Oo, 1983
Protonibea diacanthus	Blackspotted croaker	Hnin Ei Soe, 2012; Khine Khine Lin, 1983; Maw Maw Than, 1991; Mie Mie Sein, 2006a
Pterotolithus maculatus	Blotched tiger-toothed croaker	Hnin Ei Soe, 2012
Sciaena spp.	Croaker	Phyu Phyu Sin, 1983; Thi Thi Mar, 1981
Johnius coitor [recorded as *Sciaena coitor*]	Coitor croaker	Phyu Phyu Sin, 1983
Damselfish		
Abudefduf bengalensis	Bengal sergeant	This study
Abudefduf vaigiensis	Indo-Pacific sergeant	This study
Pomacentrus moluccensis	Lemon damsel	This study
Pomacentrus proteus	Columbo damsel	This study
Pomacentrus similis	Similar damsel	This study
Stegastes obreptus	Western gregory	This study
Chrysiptera rollandi	Rolland's demoiselle	This study
Dart		
Trachinotus botla	Largespotted dart	Kyaw Kyaw Htay, 2010
Emperor		
Lethrinus lentjan	Pink ear emperor	May Win Maw, 2005; This study
Lethrinus ornatus	Ornate emperor	This study
Featherback		
Notopterus notopterus	Bronze featherback	Thida Khin Khin Htun, 1998
Flathead		
Platycephalus indicus	Bartail flathead	Tint Swe, 1987; Tint Swe & Daw Tin Nu, 2012
Flounder		
Pseudorhombus arsius	Largetooth flounder	Aye Aye Maw, 1994
Pseudorhombus elevatus	Deep flounder	Tint Swe & Daw Tin Nu, 2012
Pseudorhombus javanicus	Javan flounder	Soe Thant, 1979
Flyingfish		
Exocoetus sp.	Flyingfish	This study
Fusilier		
Caesio caerulaurea	Scissortail fusilier	This study
Caesio xanthonota	Yellowback fusilier	This study
Garfish		
Xenentodon cancila	Freshwater garfish	Thida Khin Khin Htun, 1998
Goatfish		
Parupeneus barberinus	Dash-dot goatfish	This study
Parupeneus cyclostomus	Gold-saddle goatfish	Sein Thiri Htwe, 2012
Parupeneus heptacanthus	Cinnabar goatfish	Sein Thiri Htwe, 2012; Tint Swe & Daw Tin Nu, 2012

Parupeneus indicus	Indian goatfish	Sein Thiri Htwe, 2012
Parupeneus macronemus	Long-barbel goatfish	Sein Thiri Htwe, 2012
Upenus sp.	Goatfish	Tint Swe & Daw Tin Nu, 2012
Upeneus taeniopterus	Finstripe goatfish	This study
Upeneus australiae	Australian goatfish	Sein Thiri Htwe, 2012
Upeneus moluccensis	Goldband goatfish	Sein Thiri Htwe, 2012; This study
Upeneus sulphureus	Sulphur goatfish	Khine Khine Lin, 1983; Mie Mie Sein, 2006a; Sein Thiri Htwe, 2012; Tin Oo, 1983
Upeneus sulphureus [recorded as *Eupeneus sulphureus*]	Sulphur goatfish	Khine Khine Lin, 1983
Upeneus sundaicus	Ochrebanded goatfish	Sein Thiri Htwe, 2012
Upeneus tragula	Freckled goatfish	Sein Thiri Htwe, 2012; This study
Goby		
Apocryptes bato [recorded as *A. batoides*]	Goby	
Apocryptes serperaster	Goby	Thu Thu Minn, 2012
Boleophthalmus boddarti [recorded as *B. boddaerti*]	Boddart's goggle-eyed goby	Thu Thu Minn, 2012
Glossogabius sparsipapillus	Linecheek tank goby	Thu Thu Minn, 2012
Glossogobius giuris	Tank goby	Thida Aung, 2006; Thu Thu Minn, 2012
Gobius spp.	Goby	Thi Thi Mar, 1981; Thida Aung, 2006; Thu Thu Minn, 2012; This study
Odontamblyopus rubicundus	Goby	Thu Thu Minn, 2012
Pseudapocryptes elongatus [recorded as *P. lanceolatus*]	Goby	Thu Thu Minn, 2012
Taenioides buchanani	Burmese eel goby	Thu Thu Minn, 2012
Taenioides gracilis	Slender eel goby	Thu Thu Minn, 2012
Trypauchen vagina	Goby	Thu Thu Minn, 2012
Grouper		
Anyperodon leucogrammicus	Slender grouper	Tin Win, 2002
Cephalopholis argus	Peacock hind	Tin Win, 2002; This study
Cephalopholis boenak	Chocolate hind	Tin Win, 2002; This study
Cephaloholis fomosa	Bluelined grouper	This study
Cephalopholis polyspila		This study
Cromileptes altivelis	Humpback grouper	Tin Win, 2002
Epinephelus analogus	Spotted grouper	Tin Win, 2002
Epinephelus bleekeri	Duskytail grouper	May Win Maw, 2005; Tin Win, 2002; This study
Epinephelus coioides	Orange-spotted grouper	Min Thu Aung, 2006; Tin Win, 2002
Epinephelus fasciatus	Blacktip grouper	Tin Win, 2002
Epinephelus fuscoguttatus	Brown-marbled grouper	Tin Win, 2002
Epinephelus labriformis	Starry grouper	Tin Win, 2002
Epinephelus maculatus	Highfin grouper	Tin Win, 2002
Epinephelus malabaricus	Malabar grouper	Tin Win, 2002
Epinephelus megachir	Longfin grouper	Tin Win, 2002
Epinephelus merra	Honeycomb grouper	Nu Nu Aye, 1984; Tin Win, 2002

Epinephelus sexfasciatus	Sixbar grouper	Food and Agriculture Organization of the United Nations, 2003
Epinephelus tauvina	Greasy grouper	Hla Hla Win, 2004; Tin Win, 2002
Epinephelus undulosus	Wavy-lined grouper	Tin Win, 2002
Plectropomus areolatus	Squaretail coralgrouper	Tin Win, 2002
Plectropomus maculatus	Spotted coralgrouper	Tin Win, 2002
Plectropomus pessuliferus	Roving coralgrouper	Toe Nanda Tin, 2009
Grunt		
Pomadasys argenteus [recorded as *P. hasta*]	Silver grunt	Druzhinin & Phone Hlaing, 1972; Maw Maw Than, 1991; May Thet Htar Aung, 1983; Saw Nanda, 2000; Tin Oo, 1983; Tint Swe, 1987; Tint Swe & Daw Tin Nu, 2012
Pomadasys maculatus	Saddle grunt	Maw Maw Than, 1991
Rhonciscus spp.		Tint Swe *et al.*, 2011
Hairtail		
Eupleurogoammus muticus	Smallhead hairtail	Nu Nu Aye, 1984
Lepturacanthus savala	Savalai hairtail	Druzhinin & Phone Hlaing, 1972; Maw Maw Than, 1991; May Win Maw, 2005; Myint Myint Kyi, 1994
Trichiurus lepturus	Largehead hairtail	Thet Thet Myaing, 2006; Tint Swe & Daw Tin Nu, 2012; This study
Trichiurus savala [renamed *Lepturacanthus savala]*	Savalai hairtail	Druzhinin & Phone Hlaing, 1972; Myint Myint Kyi, 1994
Halfbeak		
Hemirhamphus far	Black-barred halfbeak	Tint Swe, 1987
Halibut		Soe Thant, 1979
Psettodes erumei	Indian halibut	Soe Thant, 1979; Tint Swe & Daw Tin Nu, 2012
Hump head		Soe Thant, 1979
Kurtus indicus	Indian hump head	Tint Swe & Daw Tin Nu, 2012
Ilisha		
Ilisha elongata	Elongate ilisha	Cho Cho Mar, 1988; Maw Maw Than, 1991; Min Thu Aung, 2006
Ilisha filigera		Druzhinin & Phone Hlaing, 1972
Ilisha megaloptera	Bigeye ilisha	Tint Swe & Daw Tin Nu, 2012
Ilisha novacula [recorded as *I. sladeni*]	Burmese River ilisha	Tin Oo, 1983
Labeo		
Labeo rohita	Rohu	Moe Thida Htway, 2003
Lizardfish		
Harpadon nehereus	Bombay-duck lizardfish	Khin Thida Oo, 1994; Ngu War Hlaing, 2010; Thida Khin Khin Htun, 1998; Thu Ya Kyi Zin, 2011; Tint Swe, 2011; Tint Tun *et al.*, 1991; Zaw Lunn, 1988
Harpadon nehereus [recorded as *H. nehereus*]	Bombay-duck lizardfish	Khin Thida Oo, 1994; Thida Khin Khin Htun, 1998; Thu Ya Kyi Zin, 2011; Tint Swe, 2011; Tint Swe & Daw Tin Nu, 2012; Zaw Lunn, 1988

Saurida spp.	Lizardfish	Khine Khine Lin, 1983; Maw Maw Than, 1991; Mie Mie Sein, 2006a; Min Thu Aung, 2006; Thapanand-Chaidee *et al.*, 2010; Thi Thi Mar, 1981; Tin Oo, 1983
Saurida elongata	Slender lizardfish	Tint Swe & Daw Tin Nu, 2012; This study
Saurida tumbil	Greater lizardfish	Khine Khine Lin, 1983; Maw Maw Than, 1991; Mie Mie Sein, 2006a; Min Thu Aung, 2006; Tin Oo, 1983
Saurida undosquamis	Brushtooth lizardfish	Thapanand-Chaidee *et al.*, 2010
Synodus variegatus	Reef lizardfish	This study
Lionfish		
Pterois antennata	Spotfin lionfish	This study
Mackerel		
Rastrelliger brachysoma	Short mackerel	Hnin Zar Htwe, 2012; Honey Shwe, 2012; Min Thu Aung, 2006; Pauly & Aung, 1984; Thet Thet Myaing, 2006; This study
Rastrelliger faughni	Island mackerel	Hnin Zar Htwe, 2012; Honey Shwe, 2012
Rastrelliger kanagurta	Indian mackerel	Cho Cho Mar, 1988; Hnin Zar Htwe, 2012; Honey Shwe, 2012; May Soe Oo, 1994; Min Thu Aung, 2006; Saw Nanda, 2000; Thet Swe, 1987; Tint Swe & Daw Tin Nu, 2012; This study
Rastrelliger spp.	Mackerel	Cho Cho Mar, 1988; Hnin Zar Htwe, 2012; Honey Shwe, 2012; May Soe Oo, 1994; Min Thu Aung, 2006; Moe Sapai, 1998; Saw Nanda, 2000; Thet Swe, 1987; Thet Thet Myaing, 2006
Scomberomorus commerson	Narrow-barred Spanish mackerel	Hnin Zar Htwe, 2012; Tint Swe & Daw Tin Nu, 2012; This study
Scomberomorus guttatus	Indo-Pacific king mackerel	Cho Cho Mar, 1988; Hnin Zar Htwe, 2012; May Win Maw, 2005; Min Thu Aung, 2006; Saw Nanda, 2000; Sein Moh Moh Khaing, 2011; Thida Khin Khin Htun, 1998; Tint Swe & Daw Tin Nu, 2012; Zin Zin Zaw, 2010; This study
Marlin		
Kajikia audax	Striped marlin	Kyaw Tint *et al.*, 2012b
Moony		
Psettus falciformis	Full moony	Nu Nu Aye, 1984
Moorish Idol		
Zanclus cornutus	Moorish idol	This study
Moray eel		
Gymnothorax fimbriatus	Fimbriated moray	This study
Mudskipper		
Periophthalmodon schlosseri	Giant mudskipper	Thu Thu Minn, 2012
Periophthalmus barbarus [recorded as *Periophthalmus barbarous*]	Atlantic mudskipper	Thu Thu Minn, 2012
Mullet		
Paramugil parmatus [recorded as *Liza [liza] parmata*]	Broad-mouthed mullet	Khin Maung Cho, 2009

Chelon subviridis [recorded as *Liza [liza] subviridis*]	Greenback mullet	Khin Maung Cho, 2009
Chelon planiceps [recorded as *Liza [liza] tade*]	Tade gray mullet	Khin Maung Cho, 2009; Tint Swe, 1987
Liza parsia	Goldspot mullet	Kyaw Min Naing, 2010
Ellochelon vaigiensis [recorded as *Liza vaigiensis*]	Squaretail mullet	Kyaw Min Naing, 2010
Mugil spp.		Khaing Khaing Kyi, 2010; Kyaw Min Naing, 2010
Mugil cephalus	Flathead grey mullet	Kyaw Min Naing, 2010
Valamugil speigleri [recorded as *Mugil specigleri*]	Speigler's mullet	Phyu Phyu Sin, 1983
Sicamugil hamiltoni	Burmese mullet	Khin Maung Cho, 2009
Valamugil spp.	Mullet	Kyaw Min Naing, 2010; Tint Swe, 1987
Moolgarda cunnesius [recorded as *Valamugil cunnesius*]	Longarm mullet	Kyaw Min Naing, 2010
Needlefish		
Belone strongylurus	Spottail needlefish	Than Than Naing, 2000
Tylosurus sp.	Needlefish	This study
Orbfish		
Ephippus orbis	Orbfish	Khine Khine Lin, 1983; Tint Swe & Daw Tin Nu, 2012
Parrotfish		
Scarus virdifucatus	Greenlip parrotfish	This study
Perch		
Anabas testudineus	Climbing perch	Mya Saw, 1975
Ambassis interrupta [recorded as *Ambassis interruptus*]	Long-spined glass perchlet	Tint Swe *et al.*, 2011
Ambassis vachellii	Vachelli's glass perchlet	Tint Swe *et al.*, 2011
Pomfret		
Pampus argenteus [also recorded as *Pomadasys hasta*]	Siilver grunt	Cho Cho Lwin, 1997; Kyaw Kyaw Htay, 2010; May Khin Htun, 2005; May Win Maw, 2005; Min Thu Aung, 2006; Ngu War Hlaing, 2010; Saw Nanda, 2000; Tint Swe & Daw Tin Nu, 2012; Zaw Zaw Aung, 2012
Pampus chinensis	Chinese silver pomfret	Min Thu Aung, 2006; Nu Nu Aye, 1984; Ohm Mar Myin, 1989
Pampus chinensis [recorded as *P. sinensis*]	Chinese pomfret	Ohm Mar Myin, 1989
Parastomateus niger [also recorded as *Formio niger*]	Black pomfret	May Khin Htun, 2005; May Thet Htar Aung, 1983; Tint Swe & Daw Tin Nu, 2012
Parastromateus niger [recorded as *Stromateus niger*]	Black pomfret	May Thet Htar Aung, 1983
Ponyfish		
Gazza minuta	Toothpony	Thet Lyar Win, 2012; This study
Leiognathus bindus	Orangefin ponyfish	Thet Lyar Win, 2012; This study
Leiognathus equulus	Common ponyfish	May Win Maw, 2005; Thet Lyar Win, 2012; Tint Swe, 1987; This study

Leiognathus fasciatus	Striped ponyfish	Thet Lyar Win, 2012
Leiognathus splendens	Splendid ponyfish	Thet Lyar Win, 2012; This study
Nuchequula blochii [recorded as *Leiognathus pan*]	Twoblotch ponyfish	Thet Lyar Win, 2012
Nuchequula gerreoides	Decorated ponyfish	Thet Lyar Win, 2012
Nuchequula gerreoides [recorded as *Leiognathus decorus*]	Decorated ponyfish	Thet Lyar Win, 2012
Secutor sp.	Ponyfish	This study
Secutor hanedai	Haneda's ponyfish	Thet Lyar Win, 2012
Secutor insidiator [also recorded *as Equals insidiatrix*]	Pugnose ponyfish	May Thet Htar Aung, 1983; Thet Lyar Win, 2012
Secutor ruconius	Deep pugnose ponyfish	Nu Nu Aye, 1984; Thet Lyar Win, 2012
Porcupinefish		
Diodon hystrix	Spot-fin porcupinefish	Win Win Mar, 1991; This study
Pufferfish		
Arothron sp.	Pufferfish	This study
Arothron meleagris	Guineafowl pufferfish	This study
Arothron nigropunctatus	Blackspotted pufferfish	This study
Takifugu oblongus [recorded as *Sphoeroides oblongus* and *Tetraodon oblongus]*	Lattice blaasop	Nang Mya Han, 1985; Tint Swe & Daw Tin Nu, 2012
Tetraodon spp.	Pufferfish	Tint Swe, 1987; This study
Tetraodon fluviatilis	Green pufferfish; Estuarine blowfish	Cho Cho Myint, 1997
Queenfish		
Scomberoides commersonianus	Talang queenfish	Nu Nu Aye, 1984; Tint Swe & Daw Tin Nu, 2012; This study
Scomberoides lysan	Doublespotted queenfish	This study
Raconda		
Raconda russeliana	Raconda	Tint Swe & Daw Tin Nu, 2012
Rainbow Runner		
Elagatis bipinnulata	Rainbow runner	Tint Swe & Daw Tin Nu, 2012
Remora		
Remora sp.	Remora/suckerfish	This study
Remora remora	Remora	Tint Swe & Daw Tin Nu, 2012
Ricefish		
Oryzias sp.		Cho Cho Myint, 1997; Tint Swe *et al.*, 2011
Oryzias javanicus	Javanese ricefish	Cho Cho Myint, 1997
Sailfish		
Istiophorus platypterus	Indo-Pacific Sailfish	Kyaw Tint *et al.*, 2012b
Sardine and Sardinella		
Dussumieria acuta	Rainbow sardine	Khaing Myat Myat Htwe, 2012; Tint Swe & Daw Tin Nu, 2012; This study

Escuolosa thoracata	White sardine	Khaing Myat Myat Htwe, 2012
Sardinella albella	White sardinella	Khaing Myat Myat Htwe, 2012
Sardinella fimbriata	Fringescale sardinella	Nwe Nwe Win, 1986
Sardinella gibbosa	Goldstripe sardinella	Tint Swe & Daw Tin Nu, 2012; This study
Sardinella longiceps	Indian oil sardine	Khaing Myat Myat Htwe, 2012
Scad		
Alepes djedaba	Shrimp scad	Tint Swe & Daw Tin Nu, 2012; This study
Caranx affinis	Yellowtail scad	Moh Moh Win, 1988
Megalaspis cordyla	Torpedo scad	Ei Ei Khin, 1994; Min Thu Aung, 2006; Nu Nu Aye, 1984; Tint Swe & Daw Tin Nu, 2012; This study
Selaroides sp.	Scad	This study
Selaroides leptolepis	Yellowstripe scad	Tint Swe & Daw Tin Nu, 2012
Scatophagus argus	Spotted scat	Nu Nu Aye, 1984; Nyo Nyo Than, 1987; Tint Swe, 1987
Scorpionfish		
Scorpaenopsis oxycephala	Tasseled scorpionfish	This study
Seerfish		
Scomberomorus koreanus	Korean seerfish	Hnin Zar Htwe, 2012
Shad		
Anodontostoma chacunda	Chacunda gizzard shad	Khaing Myat Myat Htwe, 2012; This study
Anodontostoma thailandiae	Thai gizzard shad	Khaing Myat Myat Htwe, 2012
Gonialosa manmina	Ganges river gizzard shad	Khaing Myat Myat Htwe, 2012
Gudusia variegata	Burmese river shad	Khaing Myat Myat Htwe, 2012
Pellona sp.	Pellona/Ilisha	This study
Tenualosa ilisha [recorded as *Hilsa ilisha*]	Hilsa shad	Cho Cho Mar, 1988; Kyu Kyu Than, 1978; Moe Sapai, 1998; Saw Nanda, 2000; This study
Tenualosa spp.	Shad	Cho Cho Mar, 1988; Hlaing Hlaing Oo, 2012; Kalayar Win Maung, 2007; Khaing Myat Myat Htwe, 2012; Kyu Kyu Than, 1978; Lei Lei Khine, 2007; Moe Sapai, 1998; Saw Nanda, 2000
Tenualosa ilisha [also recorded as *Hilsa toli*]	Hilsa shad	Cho Cho Mar, 1988; Hlaing Hlaing Oo, 2012; Kalayar Win Maung, 2007; Khaing Myat Myat Htwe, 2012; Kyu Kyu Than, 1978; Lei Lei Khine, 2007; Moe Sapai, 1998; Saw Nanda, 2000; Tint Swe & Daw Tin Nu, 2012
Tenualosa toli	Toli shad	Hlaing Hlaing Oo, 2012; Kalayar Win Maung, 2007; Khaing Myat Myat Htwe, 2012
Sicklefish		
Drepane punctata	Spotted sicklefish	May Win Maw, 2005; Tint Swe & Daw Tin Nu, 2012
Sillago		
Sillago domina	Flathead sillago or Gangetic whiting	Cho Cho Mar, 1988; Malar Tun, 1997; Moe Sapai, 1998; Thida Khin Khin Htun, 1998
Sillago sihama	Silver sillago	May Thet Htar Aung, 1983; May Win Maw, 2005; Tint Swe & Daw Tin Nu, 2012; This study

Silverside		
Atherinomorus endrachtensis	Eendracht land silverside	Tint Swe *et al.*, 2011
Atherinomorus ogilbyi	Ogilby's hardyhead	Tint Swe *et al.*, 2011
Whipfin		
Gerres erythrourus [recorded as *G. abbreviatus*]	Deep-bodied mojarra	Tint Swe & Daw Tin Nu, 2012
Gerres filamentosus	Whipfin silver-biddy	Tin Oo, 1983; Tint Swe, 1987; Tint Swe & Daw Tin Nu, 2012
Gerres oyena	Common silver-biddy	This study
Snakefish		
Channa spp.	Snakehead	Thi Thi Mar, 1981; Thida Khin Khin Htun, 1998
Channa striatus	Striped snakehead	Thida Khin Khin Htun, 1998
Snapper		
Lutjanus spp.	Snapper	Chaw Su Lwin, 2012; Druzhinin & Phone Hlaing, 1972; May Thet Htar Aung, 1983; May Win Maw, 2005; Tin Oo, 1983
Lutijanus quinquelinearis	Five-lined snapper	Phyu Phyu Win, 1992
Lutjanus bohar	Two-spot red snapper	Chaw Su Lwin, 2012
Lutjanus decussatus	Checkered snapper	Chaw Su Lwin, 2012; This study
Lutjanus ehrenbergii	Blackspot snapper	Chaw Su Lwin, 2012
Lutjanus erythropterus	Crimson snapper	May Thet Htar Aung, 1983
Lutjanus fulviflamma	Dory snapper	Chaw Su Lwin, 2012
Lutjanus johnii	John's snapper	Chaw Su Lwin, 2012; May Win Maw, 2005
Lutjanus kasmira	Common bluestripe snapper	Chaw Su Lwin, 2012
Lutjanus lutjanus [recorded as *L. lineolatus*]	Bigeye snapper	Chaw Su Lwin, 2012
Lutjanus lunulatus	Lunartail snapper	Chaw Su Lwin, 2012
Lutjanus lutjanus	Bigeye snapper	Chaw Su Lwin, 2012; This study
Lutjanus madras	Indian snapper	This study
Lutjanus malabaricus	Malabar blood snapper	Chaw Su Lwin, 2012; May Win Maw, 2005; Tint Swe & Daw Tin Nu, 2012
Lutjanus quinquelineatus	Five-lined snapper	This study
Lutjanus rufolineatus	Yellow-lined snapper	This study. Confirmation needed.
Lutjanus russelli	Russell's snapper	Chaw Su Lwin, 2012; May Win Maw, 2005; This study
Lutjanus sanguineus	Humphead snapper	Tin Oo, 1983
Lutjanus sebae	Emperor red snapper	Chaw Su Lwin, 2012; Tint Swe & Daw Tin Nu, 2012
Lutjanus timoriensis	Timor snapper	This study
Lutjanus vitta	Brownstripe red snapper	Chaw Su Lwin, 2012; This study
Soapfish		
Diploprion bifasciatum	Doublebanded soapfish	This study
Solderfish		

Myripristis hexagona	Double-tooth soldier-fish	This study
Sole		
Brachirus pan [recorded as *Synaptura pan*]	Pan sole	Soe Thant, 1979
Zebrias zebra [recorded as *Synaptura zebra*]	Zebra sole	Soe Thant, 1979
Spinefoot		
Siganus fuscescens	Mottled spinefoot	This study
Siganus javus	Streaked spinefoot	Nu Nu Aye, 1984; Tint Swe & Daw Tin Nu, 2012
Siganus puelloides	Blackeye rabbitfish	This study
Spineless eel		
Chaudhuria caudata	Burmese spineless eel	Htwe Htwe Khine, 1999
Spiny eel		Htwe Htwe Khine, 1999
Macrognathus aculeatus	Lesser spiny eel	Htwe Htwe Khine, 1999
Mastacembelus alboguttatus	Spiny eel	Htwe Htwe Khine, 1999
Mastacembelus armatus	Zig-zag eel	Htwe Htwe Khine, 1999
Mastacembelus caudiocellatus	Spiny eel	Htwe Htwe Khine, 1999
Mastacembelus oatesii	Spiny eel	Htwe Htwe Khine, 1999
Mastacembelus unicolor	Spiny eel	Htwe Htwe Khine, 1999
Mastacembelus zebrinus	Zebra spiny eel	Htwe Htwe Khine, 1999
Sprat		
Corica soborna	Ganges river sprat	Khaing Myat Myat Htwe, 2012
Surgeonfish		
Acanthurus sp.	Surgeonfish	This study
Sweetlips		
Plectorhinchus sp.	Sweetlips	This study
Plectorhinchus vittatus	Oriental sweetlips	This study
Swordfish		
Xiphias gladius	Swordfish	Kyaw Tint *et al.*, 2012b
Tarpon		
Megalops cyprinoides	Indo-Pacific tarpon	This study
Terapon		
Therapon spp. [also called *Terapon*]	Terapon	Khine Khine Lin, 1983; Mie Mie Sein, 2006a; Ohn Mar Han, 1996; Tint Swe, 1987
Therapon jarbua	Jarbua terapon	Ohn Mar Han, 1996; Tint Swe, 1987; Tint Swe & Daw Tin Nu, 2012; This study
Therapon theraps	Largescaled terapon	Khine Khine Lin, 1983; Mie Mie Sein, 2006a; This study
Threadfin		
Alectis ciliaris	African pompano	Tint Swe & Daw Tin Nu, 2012
Alectis indlcus	Indian threadfin	Nu Nu Aye, 1984; Thint Thint Aung, 1994; Tint Swe & Daw Tin Nu, 2012
Eleutheronema tetradactylum	Fourfinger threadfin	Min Thu Aung, 2006; Tint Swe & Daw Tin Nu, 2012

Leptomelanosoma indicum	Indian threadfin	Khin Nwe Mu, 1980; Khine Khine Lin, 1983; May Khin Htun, 2005; May Win Maw, 2005; Mie Mie Sein, 2006a; Min Thu Aung, 2006; Saw Nanda, 2000; Sein Moh Moh Khaing, 2011; Tin Oo, 1983
Polydactylus indicus [recorded as *Leptomelanosoma indicum*]	Indian threadfin	May Win Maw, 2005
Polynemus spp.	Threadfin	Khin Swe Thoung, 1977; Khine Khine Lin, 1983; May Khin Htun, 2005; Mie Mie Sein, 2006a; Min Thu Aung, 2006; Ngu War Hlaing, 2010; Phyu Phyu Sin, 1983; Saw Nanda, 2000; Sein Moh Moh Khaing, 2011; Soe Moe Htun, 2010; Thi Thi Mar, 1981; Thida Aung, 2006; Thu Ya Kyi Zin, 2011; Tin Oo, 1983
Leptomelanosoma indicum [recorded as Polynemus indicus]	Indian threadfin	Khine Khine Lin, 1983; May Khin Htun, 2005; Mie Mie Sein, 2006a; Min Thu Aung, 2006; Pauly & Aung, 1984; Saw Nanda, 2000; Sein Moh Moh Khaing, 2011; Tin Oo, 1983
Polynemus paradiseus	Paradise threadfin	Khin Swe Thoung, 1977; Ngu War Hlaing, 2010; Phyu Phyu Sin, 1983; Soe Moe Htun, 2010; Thida Aung, 2006; Thu Ya Kyi Zin, 2011; Tint Swe & Daw Tin Nu, 2012
Thryssa		
Thryssa hamiltonii	Hamilton's thryssa	Tint Swe, 1987; Tint Swe & Daw Tin Nu, 2012
Thryssa setirostris	Longjaw thryssa	Tint Swe & Daw Tin Nu, 2012
Toadfish		
Batrachus spp.	Toadfish	Thi Thi Mar, 1981; Thida Khin Khin Htun, 1998
Tonguesole		
Cynoglossus arel	Largescale tonguesole	Sabai Soe, 2012
Cynoglossus bilineatus	Fourlined tonguesole	Sabai Soe, 2012; Soe Thant, 1979
Cynoglossus cynoglossus	Bengal tonguesole	Sabai Soe, 2012; Tint Swe & Daw Tin Nu, 2012
Cynoglossus lingua	Long tonguesole	Sabai Soe, 2012; Soe Thant, 1979
Cynoglossus oligolepis	Tonguesole	Soe Thant, 1979
Cynoglossus bilineatus [recorded as *C. quinquelineatus*]	Fourlined tonguesole	Soe Thant, 1979
Trevally		
Atropus atropos	Cleftbelly trevally	Tint Swe & Daw Tin Nu, 2012; This study
Carangoides chrysophrys	Longnose trevally	Nu Nu Aye, 1984; Tint Swe & Daw Tin Nu, 2012
Carangoides ferdau	Blue trevally	Tint Swe & Daw Tin Nu, 2012; This study
Carangoides malabaricus	Malabar trevally	May Win Maw, 2005; Tint Swe & Daw Tin Nu, 2012
Caranx sexfasciatus	Bigeye trevally	Moe Sapai, 1998; Thida Khin Khin Htun, 1998; This study
Gnathanodon speciosus	Golden trevally	Nu Nu Aye, 1984; Tint Swe & Daw Tin Nu, 2012
Lactarius lactarius	False trevally	May Win Maw, 2005; Tint Swe & Daw Tin Nu, 2012; This study
Tripodfish		
Triacanthus sp	Tripodfish	Tint Swe & Daw Tin Nu, 2012
Triggerfish		

Abalistes sp.	Triggerfish	Tint Swe & Daw Tin Nu, 2012
Sufflamen chrysopterus	Flagtail triggerfish	Min Thu Aung, 2006
Tripletail		
Lobotes surinamensis	Tripletail	Min Thu Aung, 2006
Tuna		
Auxis thazard thazard [recorded as *A. thazard*]	Frigate tuna	Hnin Zar Htwe, 2012
Euthynnus affinis	Kawakawa	Hnin Zar Htwe, 2012; Kyaw Kyaw Htay, 2010; This study
Thunnus albacares	Yellowfin tuna	Kyaw Tint *et al.*, 2012b
Thunnus tonggol	Longtail tuna	Hnin Zar Htwe, 2012; Thet Thet Myaing, 2006
Wallago		
Wallago attu	Wallago	Thida Khin Khin Htun, 1998
Wolf-herring		
Chirocentrus dorab	Blackfin wolf-herring	Sanda Soe Tin, 1992; Saw Nanda, 2000; Tint Swe & Daw Tin Nu, 2012; This study
Chirocentrus nudus	Whitefin wolf-herring	Ngu War Hlaing, 2010
Wrasse		
Cheilinus chlorourus	Floral wrasse	This study
Cheilinus fasciatus	Redbreasted wrasse	This study
Cirrhilabrus cyanopleura	Bluesided wrasse	This study
Haliocheres hortulanus	Checkerboard wrasse	This study
Halichoeres melanurus	Pinstriped wrasse	This study
Labroides dimidatus	Cleaner wrasse	This study
Leptojulis cyanopleura	Shoulder-spot wrasse	This study
Thalassoma lunare	Crescent wrasse	This study

APPENDIX 7. SHARKS AND RAYS OF MYANMAR

Scientific Name	Common Name	CITES	IUCN	Occurrence	Citations)
Sharks					
Atelomycterus marmoratus	Marble cat shark		NT	Probable	2
Carcharhinus albimarginatus	Silvertip shark		NT	Possible?	5, 6
Carcharhinus amblyrhynchoides	Graceful shark		NT	Confirmed	3, 5
Carcharhinus amboinensis	Pigeye shark		DD	Confirmed	5
Carcharhinus borneensis	Borneo shark		EN	Confirmed	5, 6
Carcharhinus brevipinna	Spinner shark		NT	Confirmed	3, 5, 6
Carcharhinus dussumieri	Whitecheek shark		NT	Confirmed	2, 5, 6
Carcharhinus falciformis	Silky shark		NT	Confirmed	3, 5, 6
Carcharhinus galapagensis	Galapagos shark		NT	Unlikely	5
Carcharhinus leucas	Bull shark		NT	Confirmed	3, 5, 6, 7
Carcharhinus limbatus	Blacktip shark		NT	Confirmed	2, 5, 6
Carcharhinus longimanus	Oceanic whitetip shark	II - Sept 14, 2014	VU	Probable	2
Carcharhinus melanopterus	Blacktip reef shark		NT	Confirmed	3, 5, 6
Carcharhinus plumbeus	Sandbar shark		VU	Confirmed	5, 6
Carcharhinus sealei	Blackspot shark		NT	Possible	2
Carcharhinus sorrah	Spottail shark		NT	Confirmed	3, 5, 6
Chaenogaleus macrostoma	Hooktooth shark		VU	Probable	5, 6
Chiloscyllium griseum	Grey bamboo shark		NT	Confirmed	5, 6
Chiloscyllium punctatum	Brownbanded bamboo shark		NT	Confirmed	3, 5, 6
Chioscyillium griseum	Ray bamboo-shark		NT	Confirmed	2, 5
Eusphyra blochii [recorded as *Sphyrna blochii*]	Winghead shark		NT	Probable	2, 5

Galeocerdo cuvier	Tiger shark		NT	Confirmed	3, 5, 6
Glyphis gangeticus	Ganges shark		CR	Confirmed	5, 6
Hemigaleus microstoma	Sickelfin weasel shark		VU	Possible	5
Hemipristis elongata	Snaggletooth shark		VU	Confirmed	5
Hemipristis elongatus	Snaggletooth shark		VU	Confirmed	3
Loxodon macrorhinus	Sliteye shark		LC	Confirmed	3, 5, 6
Rhincodon typus	Whale shark	II	VU	Probable	2
Rhizoprionodon acutus [recorded as *Scoliodon walbeehmi*]	Milk shark		LC	Probable	2, 5, 6
Rhizoprionodon oligolinx	Grey sharpnose shark		LC	Confirmed	3, 6
Scoliodon laticaudus	Spadenose shark		NT	Confirmed	3, 5, 6, 7
Sphyrna lewini	Scalloped hammerhead	II - Sept 14, 2014	EN	Confirmed	3, 5, 6, 7
Sphyrna mokarran	Great hammerhead shark	II - Sept 14, 2014	EN	Probable	2, 5, 6
Sphyrna zygaena	Smooth hammerhead shark	II - Sept 14, 2014	VU	Confirmed	4
Stegostoma fasciatum	Leopard shark		VU	Confirmed	5, 6
Rays					
Aetobatis narinari	Spotted eagle ray		NT	Probable	2, 5
Aetomylaeus nichofii	Banded eagle ray		VU	Probable	2, 5
Aetomylaeus vespertilio	Ornate eagle ray		EN	Possible	5
Anoxypristis cuspidata	Narrow sawfish	I	EN	Probable	1, 2
Dasyatis fluviorum	Estuary stingray		VU	Unlikely	5
Dasyatis sinensis	Chinese stingray		DD	Unlikely	5
Dasyatis zugei	Pale-edged stingray		NT	Possible	5
Dasyatis zugei [recorded as *Amphotistius zugei*]	Pale-edged stingray		NT	Possible	2

Gymnura poecilura	Longtail butterfly ray		NT	Probable	5
Gymnura zonura [recorded as *Aetomylaeus zonura*]	Zonetail butterfly ray		VU	Probable	5
Himantura fai	Pink whipray		LC	Confirmed	5
Himantura gerrardi	Whitespotted whipray		VU	Confirmed	5
Himantura imbricata	Scaly whipray		DD	Probable	5
Himantura jenkinsii	Jenkins whipray		LC	Confirmed	5
Himantura toshi	Brown whipray		LC	Unlikely	5
Himantura uarnacoides	Bleeker's whipray		VU	Probable	2
Himantura uarnak	Reticulate whipray		VU	Probable	2, 5
Himantura undulata	Bleeker's variegated whipray		VU	Confirmed	5
Himantura walga	Dwarf whipray		NT	Possible	5
Manta alfredi	Reef manta ray	II - Sept 14, 2014	VU	Possible	2
Manta birostris	Giant manta ray	II - Sept 14, 2014	VU	Probable	2
Mobula sp.	Devil ray			Probable	5
Narcine timlei	Electric ray		DD	Probable	2
Neotrygon annotata [recorded as *Dasyatis annotata*]	Brown stingray		NT	Possible?	5
Neotrygon kuhlii [also recorded as *Dasyatis kuhli*]	Blue-spotted stingray		DD	Confirmed	2, 5
Pastinachus sephen	Cowtail stingray		DD	Unlikely	2, 5, 7
Pristis clavata	Dwarf sawfish	I	EN	Possible	1
Pristis pristis	Largetooth sawfish	I	CR	Probable	1
Pristis zijsron	Green sawfish	I	CR	Probable	1
Rhinoptera javanica	Javanese cownose ray		VU	Probable	2, 5
Rhynchobatus djiddensis	White-spotted guitarfish		VU	Unlikely	5
Urogymnus asperrimus	Porcupine ray		VU	Confirmed	7

*Citations	
1	Harrison & Dulvy, 2014
2	IUCN, Web page
3	Khaing Khaing Thein, 2008
4	Kyi Win, 1978
5	Maung Hla & Thein Thein Kyi, 2012
6	National Biodiversity Strategy and Action Plan, 2011
7	San San Khine, 2010

APPENDIX 8. SEA AND COASTAL BIRDS OF MYANMAR

Scientific Name	Common Name	IUCN	Coastal Region		
			Cocos	Rakhine	Tanin.
Family Megapodiidae: Scrubfowl					
Megapodius nicobariensis	Nicobar scrubfowl	VU	X		
Family Hydrobatidae, Subfamily Oceanitinae: Oceanites storm-petrels					
Oceanites oceanicus	Wilson's storm-petrel	n/a			X
Family Ardeidae, Subfamily Ardeinae: Herons & egrets					
Ardea sumatrana	Great-billed heron	n/a			X
Egretta sacra	Pacific reef egret	n/a		X	X
Family Phaethontidae: Tropicbirds					
Phaethon aethereus	Red-billed tropicbird	n/a			X
Phaethon lepturus	White-tailed tropicbird	n/a			X
Family Fregatidae: Frigatebirds					
Fregata minor	Great frigatebird	n/a			X
Family Sulidae: Boobies					
Sula leucogaster	Brown booby	n/a			X
Sula sula	Red-footed booby	n/a			X
Family Heliornithidae: Finfoots					
Heliopais personata	Masked finfoot	EN			X
Family Burhinidae: Thick-knees					
Esacus neglectus	Beach Thick-knee	NT			X
Family Pluvialidae: Plivialis plovers					
Pluvialis fulva	Pacific golden plover	n/a			X
Pluvialis squatarola	Grey plover	n/a			X
Family Recurvirostridae: Stilts & avocets					
Himantopus himantopus	Black-winged stilt	n/a		X	X
Family Haematopodidae: Oystercatchers					
Haematopus ostralegus	Eurasian oystercatcher	n/a		X	
Family Dromadidae: Crab-plover					
Dromas ardeola	Crab-plover	n/a			X
Family Charadriidae: Charadrius plovers & allies					
Charadrius alexandrinus	Kentish plover	n/a		X	X
Charadrius dubius	Little ringed plover	n/a			X
Charadrius hiaticula	Common ringed plover	n/a		X	
Charadrius leschenaultii	Greater sand-plover	n/a		X	X
Charadrius mongolus	Lesser sand-plover	n/a		X	X
Charadrius peronii	Malaysian plover	n/a			X
Family Scolopacidae, Subfamily Tringinae: Godwits, dowitchers, curlews, sandpipers & allies					
Actitis hypoleucos	Common sandpiper	n/a		X	X
Limnodromus semipalmatus	Asian dowitcher	NT			X
Limosa lapponica	Bar-tailed godwit	n/a		X	
Limosa limosa	Black-tailed godwit	NT		X	X

Numenius arquata	Eurasian curlew	NT	X	X
Numenius menutus	Little curlew	n/a		X
Numenius phaeopus	Whimbrel	n/a	X	X
Tringa erythropus	Spotted redshank	n/a	X	X
Tringa glareola	Wood sandpiper	n/a	X	X
Tringa guttifer	Nordmann's greenshank	EN		X
Tringa nebularia	Common greenshank	n/a	X	X
Tringa ochropus	Green sandpiper	n/a	X	X
Tringa stagnatilis	Marsh sandpiper	n/a	X	X
Tringa totanus	Common redshank	n/a	X	X
Xenus cinereus	Terek sandpiper	n/a	X	X
SCOLOPACIDAE: CALIDRIDINAE: Calidris sandpipers & allies				
Calidris alba	Sanderling	n/a		
Calidris canutas	Red knot	n/a	X	X
Calidris ferruginea	Curlew sandpiper	n/a	X	X
Calidris minuta	Little stint	n/a	X	X
Calidris pygmeus	Spoon-billed sandpiper	CR	X	
Calidris ruficollis	Red-necked stint	n/a	X	X
Calidris subminuta	Long-toed stint	n/a	X	X
Calidris temminckii	Temminck's stint	n/a	X	X
Calidris tenuirostris	Great knot	VU	X	X
Limicola falcinellus	Broad-billed sandpiper	n/a	X	X
Philomarchus pugnax	Ruff	n/a	X	X
Family Scolopacidae, Subfamily Subfamily Calidridinae: Calidris sandpipers & allies				
Arenaria interpres	Ruddy turnstone	n/a	X	X
Family Stercorariidae: Jaegers & allies				
Stercorarius pomarinus	Pomarine jaeger	n/a		X
Family Rhynchopidae: Skimmers				
Rynchops albicollis	Indian skimmer	VU	X	
Family Sternidae: Noddies & terns				
Anous stolidus	Brown noddy	n/a		X
Chlidonias hybridus	Whiskered tern	n/a	X	X
Chlidonias leucopterus	White-winged tern	n/a		X
Gelocbelidon nilotica	Gull-billed tern	n/a	X	X
Hydroprogne caspia	Caspian tern	n/a		
Onychoprion fuscata	Sooty tern	n/a		X
Sterna acuticauda	Black-bellied tern	EN	X	X
Sterna aurantia	River tern	NT	X	X
Sterna dougallii	Roseate tern	n/a		X
Sterna hirundo	Common tern	n/a		X
Sterna sumatrana	Black-naped tern	n/a		X
Sternula albifrons	Little tern	n/a	X	X
Thalasseus bengalensis	Lesser crested tern	n/a	X	X
Thalasseus bergii	Great creasted tern	n/a	X	X

Family Laridae: Gulls & allies					
Chricocephalus brunnicephalus	Brown-headed gull	n/a		X	
Chricocephalus ridibundus	Black-headed gull	n/a		X	X
Larus ichthyaetus	Pallas's gull	n/a		X	X
Family Columbidae, Subfamily Columbinae: Typical pigeons & doves					
Caloenas nicobarica	Nicobar pigeon	NT			X
Columba punicea	Pale-capped pigeon	VU		X	X
Family Columbinae, Subfamily Treroninae: Green-pigeons, fruit-doves, imperial-pigeons & allies					
Ducula bicolor	Pied Imperial-pigeon	n/a		X	X
Treron capellei	Large green-pigeon	VU			X
Treron chloropterus	Andaman green-pigeon	n/a	X		
Treron fulvicollis	Cinnamon-headed green-pigeon	NT			X
Family Cuculidae, Subfamily Centropodinae: Coucals					
Centropus andamanensis	Andaman coucal	n/a	X		
Family Apodida, Subfamily Apodinae: Typical swifts					
Aerodramus fuciphaga	Edible-nest swiftlet	n/a			X
Aerodramus germani	Germain swiftlet	n/a			X
Aerodramus maxima	Black-nest swiftlet	n/a			X
Family Alcedinidae: River kingfishers					
Pelargopsis amauroptera	Brown-winged kingfisher	NT		X	X
Family Halcyonidae, Tree kingfishers					
Halcyon coromanda	Ruddy kingfisher	n/a			X
Todiramphus chloris	Collared kingfisher	n/a		X	X
Family Bucerotidae: Hornbills					
Aceros subruficollis	Plain-pouched hornbill	VU			X
Family Pittidae: Pittas					
Pitta megarhyncha	Mangrove pitta	NT		X	X
Family Acanthizidae: Gerygones & allies					
Gerygone sulphurea	Golden-bellied gerygone	n/a			X
Family Pachycephalidae: Whistlers & allies					
Pachycephala cinerea	Mangrove whistler	n/a		X	X
Family Dicruridae: Drongos					
Dicrurus andamanensis	Andaman drongo	NT	X		

(Robson, 2008)

APPENDIX 9. PRAWNS AND SHRIMPS OF MYANMAR

Scientific Name	Common Name	IUCN	Occurrence	*Citation(s)	Marine	Brackish	Fresh
Marine Shrimps/Prawns							
Family Alpheidae							
Alpheus euphrosyne	Snapping shrimp	n/a	Probable	26	X		
Family Atyidae							
Atyopsis spp.		(LC)	Probable	25	X	X	
Family Hippolytidae							
Exhippolysmata ensirostris ensirostris [recorded as *Hippolysmata ensirostris*]	Hunter shrimp	n/a	Confirmed	25	X		
Family Padalidae							
Heterocarpus woodmasoni	Indian nylon shrimp	n/a	Possible	20	X		
Plesionika martia	Golden shrimp	n/a	Possible	20	X		
Plesionika spinipes [recorded as *Parapandalus spinipes*]	Oriental narwal shrimp	n/a	Possible	20	X		
Family Palaemonidae							
Exopalaemon styliferus [also recorded as *Leander styliferus*]	Roshma prawn	n/a	Confirmed	11, 22, 25, 28	X	X	
Palaemon semmelinkii		n/a	Confirmed	25	X		
Palaemon serrifer	Barred estuarine shrimp	n/a	Probable	25	X		
Family Penaeidae							
Alcockpenaeopsis hungerfordii [recorded as *Parapenaeopsis hungerfordi*]		n/a	Confirmed	5, 19, 28	X		
Ganjampenaeopsis uncta [recorded as *Parapenaeopsis probata*]		n/a	Possible	19, 28	X		
Kishinouyepenaeopsis maxillipedo [recorded as *Parapenaeopsis maxillipedo*]	Torpedo shrimp	n/a	Confirmed	5, 25, 27, 28			
Megokris pescadoreensis [recorded as *Trachypeneus pescadoreensis*]	Big head king prawn	n/a	Possible	19, 28	X		
Metapenaeopsis andamanensis		n/a	Probable	20	X		
Metapenaeopsis barbata	Sand prawn/ Whiskered velvet prawn	n/a	Possible	19	X		
Metapenaeopsis palmensis [recorded as *M. barbeensis*]		n/a	Confirmed	5, 19, 28	X		

Metapenaeopsis stridulans	Fiddler shrimp	n/a	Confirmed	5, 19	X	
Metapenaeus affinis	Pink/Jinga prawn	n/a	Confirmed	5, 19	X	
Metapenaeus brevicornis	Yellow shrimp	n/a	Confirmed	5, 11, 13, 27	X	
Metapenaeus dobsoni	Kadal shrimp	n/a	Probable	19	X	
Metapenaeus ensis	Greasyb-ack shrimp	n/a	Confirmed	5, 19	X	
Metapenaeus lysianassa	Small white/Bird prawn	n/a	Confirmed	5, 11, 12, 16	X	
Metapenaeus monoceros	Speckled prawn	n/a	Confirmed	11, 12, 13	X	
Metapenaeus tenuipes		n/a	Confirmed	5, 19	X	
Nematopalaemon tenuipes [recorded as *Palaemon tenuipes*]	Spider prawn	n/a	Confirmed	5, 11, 25, 28	X	
Parapenaeopsis cornuta	Coral shrimp	n/a	Confirmed	5, 19	X	
Parapenaeopsis hardwickii	Spear shrimp	n/a	Confirmed	5, 6, 11	X	
Parapenaeopsis sculptilis	Coral prawn	n/a	Confirmed	5, 25, 27	X	
Parapenaeopsis stylifera	Kiddi shrimp	n/a	Possible	11	X	
Parapenaeopsis tenella		n/a	Confirmed	5, 19	X	
Parapenaeus fissurus		n/a	Probable	19	X	
Parapenaeus longipes	Flamingo shrimp	n/a	Probable	19	X	
Penaeus canaliculatus	Witch prawn	n/a	Possible	19	X	
Penaeus indicus	Indian white prawn	n/a	Confirmed	3, 5, 11, 12	X	X
Penaeus japonicus	Kuruma shrimp	n/a	Confirmed	3, 5		
Penaeus latisulcatus	Western king prawn	n/a	Confirmed	5, 19	X	
Penaeus merguiensis	Banana prawn	n/a	Confirmed	5, 13, 21		X
Penaeus monodon	Giant tiger prawn	n/a	Confirmed	2, 4, 5, 7, 8, 9, 11, 12, 13, 14, 17, 18, 21, 23, 24	X	X
Penaeus penicillatus	Redtail shrimp	n/a	Probable	19	X	
Penaeus semisulcatus	Green tiger prawn	n/a	Confirmed	3, 5	X	
Trachysalambria aspera		n/a	Confirmed	5, 19	X	

Trachysalambria curvirostris [FAO recorded as *Trachypenaeus curvirostris*]	Southern rough shrimp	n/a	Probable	3, 28	X		
Trachysalambria fulva	Big head king prawn	n/a	Possible	19	X		
Family Sergestidae							
Acetes indicus		n/a	Confirmed	5, 25	X	X	
Acetes japonicus [recorded as *A. cochinensis*]	Akiami paste shrimp	n/a	Probable	3, 28	X		
Family Solenoceridae							
Solenocera crassicornis [recorded as *S. indica* and *S. subnuda*]		n/a	Confirmed	5, 19, 28	X		
Solenocera spp.		n/a	Probable	11	X		
Solenocera alticarinata		n/a	Possible	19	X		
Solenocera melantho		n/a	Possible	19	X		
Family Squillidae							
Harpiosquilla raphidea	Mantis shrimp	n/a	Confirmed	10, 15		X	
Miyakella nepa [recorded as *M. nepa*]	Mantis shrimp	n/a	Probable	15, 28	X		
Freshwater Shrimps/Prawns							
Macrobrachium rosenbergii	Giant river prawn	LC	Confirmed	1, 5, 11, 12, 21, 25			X
Macrobrachium villosimanus	Dimua river prawn	LC	Confirmed	11, 25			X
Macrobrachium idea		LC	Probable	11			X
Macrobrachium malcolmsonii malcolmsonii	Monsoon river prawn	LC	Probable	11, 12			X
Macrobrachium scabriculum	Goda river prawn	LC	Probable				X
Macrobrachium mirabile	Shortleg river prawn	n/a	Possible	11			X
Macrobrachium rude	Hairy river prawn	LC	Possible	11			X
Caridina spp.	Cardinal shrimp	LC to EN	Probable	25			X

*Citations			
1	Ahmed *et al*., 2013	15	Myo Nandar Myint, 2012
2	Aung Myo Htay, 2005	16	Nant Nay Chit Latt, 2009
3	Food and Agriculture Organization, Web page-b	17	Nwe Nwe Ni, 1998
4	Hlaing Hlaing Oo, 2005	18	Moe Swe, 2012
5	Htay Aung, 2004	19	OBIS, *Web p*age
6	Htay Htay Win, 1977	20	Pont Pont Phyu, 1992
7	Htoo Thant, 1987	21	San San Yi, 1997
8	Khin Htwe Yi, 2000	22	Sein Moh Moh Khaing, 2011
9	Khin Khin Htay, 1998	23	Swe Swe Myint, 2007
10	Khin Myint Zin, 1984	24	Than Htaike, 1999
11	Khin Nwe Mu, 1980	25	Than Than Soe, 2012
12	Khin Wai Hlaing, 2012	26	Thanda Win, 2011
13	Kyi Kyi Myint, 1982	27	Thiri Tun, 2010
14	Myo Min Hlaing, 1999	28	World Register of Marine Species, Web page

APPENDIX 10. LOBSTERS OF MYANMAR

Scientific Name	Common Name	IUCN	Occurrence	*Citation(s)	Coastal Region	
					Rakhine	Tanin.
Spiny Lobsters						
Panulirus homarus	Scalloped spiny lobster	LC	Confirmed	1, 3, 5		X
Panulirus longipes	Longlegged spiny lobster	LC	Confirmed	1	X	X
Panulirus ornatus	Ornate spiny lobster	LC	Confirmed	1, 4	X	X
Panulirus polyphagus	Mud spiny lobster	LC	Confirmed	1	X	X
Panulirus versicolor	Common rock lobster	LC	Confirmed	1	X	X
Thenus orientalis	Flathead lobster	LC	Confirmed	1, 2		X
Lobsters (Other)						
Gibbularctus gibberosus		LC	Probable	2		
Metanephrops andamanicus	Andaman lobster	LC	Probable	2, 4		
Nephropsis carpenteri	Ridge-back lobsterette	LC	Probable	2, 4		
Nephropsis ensirostris	Gladiator lobsterette	LC	Probable	2, 4		
Nephropsis stewarti	Indian Ocean lobsterette	LC	Probable	2		
Pentacheles gibbus		LC	Probable	2, 4		
Petrarctus veliger	Slipper lobster	LC	Probable	2, 4		
Biarctus sordidus	Pygmy slipper lobster	LC	Possible	2		
Stereomastis cerata		LC	Possible	2		

*Citations	
1	Htay Aung, 2004
2	IUCN
3	Kumar *et al.*, 2010
4	OBIS, *Web* page
5	Win Win Si, 2011

APPENDIX 11. CRABS OF MYANMAR

Scientific Name	Common Name	Occurrence	*Citation(s)	Marine	Brackish	Mangroves	Beaches
Ashtoret lunaris [recorded as *Matuta lunaris*]		Possible	5, 12, 19	X			
Calappa japonica		Confirmed	5	X			
Calappa lophos		Confirmed	5	X			
Carcinoscorpius rotundicauda [also recorded as *Tachypleus rotundicauda*]	Mangrove horseshoe crab	Probable	6, 17, 19	X			
Charybdis annulata		Confirmed	5	X			
Charybdis callianassa		Confirmed	5	X			
Charybdis feriata	Coral crab	Confirmed	4, 5, 11	X			
Charybdis hellerii [recored as *C. merguiensis*]	Mangrove crab	Confirmed	5, 19	X			
Clistocoeloma spp.	Mangrove crab	Confirmed	5	X			
Dardanus lagopodes [recorded as *Pagurus euopsis*]	Hermit crab	Probable	10, 12, 19	X			
Doclea rissoni [recorded as *D. andersoni*]		Confirmed	5, 19	X			
Dorippoides facchino [recorded as *Dorippe astuta*]	Anenome-carrying crab	Confirmed	5, 19	X			
Dotilla myctiroides	Soldier crab	Confirmed	5				X
Episesarma versicolor		Possible	7	X	X	X	
Etisus laevimanus		Confirmed	5	X			
Gelasimus tetragonon		Confirmed	5				X
Grapsus albolineatus [recorded as *G. strigosus*]		Possible	5, 12, 19	X			
Lauridromia dehaani [recorded as *Dromia dehaani*]	Sponge crab	Possible	5, 19	X			
Leptodius exaratus		Confirmed	5				
Macrophthalmus depressus		Confirmed	5				X
Matuta planipes		Confirmed	5	X			
Metaplax dentipes		Possible	7	X			
Metaplax elegans		Confirmed	1	X			
Metopograpsus messor	Alamihi	Probable	7		X	X	
Neosarmatium meinerti [recorded as *Sesarma meinerti*]			1, 19			X	
Ocypode stimpsoni	Ghost crab	Unlikely	5, 12	X			X
Perisesarma bidens [recorded as *Sesarma bidens*]		Confirmed	4	X		X	
Pilumnus vespertilio		Probable	5	X			
Portunus pelagicus	Blue swimming crab	Confirmed	2, 4, 5	X	X		

Portunus sanguinolentus	Repspot swimming crab	Confirmed	4, 5, 11		X		
Portunus trituberculatus	Gazami crab	Probable	2	X			
Pseudosesarma edwardsii		Confirmed	16		X	X	
Ranina ranina	Frog crab	Confirmed	4, 11		X		
Scopimera globosa	Mangrove crab	Possible	5				X
Scylla olivacea	Orange mud crab	Probable	13, 18	X	X		
Scylla serrata	Giant mud crab	Confirmed	3, 5, 7, 8, 9, 14, 15	X	X	X	
Thalamita prymna		Confirmed	5	X			
Uca (Austruca) annulipes [recorded as *Gelasimus annulipes*]		Confirmed	5, 19				X
Uca (Austruca) lactea [recorded as *Gelasimus lactea*]	Fiddler crab	Probable	7, 19	X			
Uca (Gelasimus) vocans [recorded as *G. marionis* and *G. marionis nitidus*]	Fiddler crab	Probable	7, 12, 19	X			
Uca spp.	Fiddler crab	Confirmed	3	X			
Varuna litterata	Hairy crab	Possible	5, 16	X	X		

***Citations**			
1	Duncan *et al.*, 1889a	11	OBIS, *Web p*age
2	Food and Agriculture Organization, Web page-b	12	San San Yi, 1997
3	Hla Hla Win, 2009	13	San Tha Tun, 2011
4	Htay Aung, 2004	14	Saw Htoo Baw, 1978
5	Isituto Oikos, 2011	15	Thanda Win, 2011
6	Khin Soe Nwe, 1979	16	Thet Su Mar, 2010
7	Khin Wai Hlaing, 2012	17	Thi Thi Mar, 2009
8	Kyi Kyi Maw, 2007	18	Thinzar Lwin Lwin, 2011
9	Ma Kyin Nwe, 1981	19	World Register of Marine Species, Web page
10	Mg Mg Gyi, 1993		

APPENDIX 12. CEPHALOPODS OF MYANMAR

Scientific Name	Common Name	IUCN	Occurrence	*Citation(s)
Order Teuthida: Squids				
Ancistrocheirus lesueuri	Sharpear enope squid	n/a	Probable	2
Brachioteuthis picta	Ornate arm squid	n/a	Probable	2
Brachioteuthis riisei	Common arm squid	n/a	Probable	2
Chiroteuthis veranyi	Long-armed squid	n/a	Probable	2
Chtenopteryx sicula	Toothed-fin squid	n/a	Probable	2
Euprymna berryi	Hummingbird bobtail squid	DD	Possible	2, 8
Euprymna hyllebergi	Bobtail squid	DD	Probable	3, 5
Euprymna morsei	Mimika bobtail squid	DD	Possible	2
Inioteuthis maculosa	Bobtail squid	LC	Probable	3
Nototodarus hawaiiensis	Hawaiian flying squid	n/a	Probable	2
Octopoteuthis sicula	Ruppell's octopus squid	n/a	Probable	2
Onychoteuthis banksi	Common clubhook squid	n/a	Probable	2
Ornithoteuthis volatilis	Shiny bird squid	n/a	Probable	2
Pterygioteuthis giardi	Roundear enope squid	n/a	Probable	2
Pyroteuthis margaritifera	Jewel enope squid	n/a	Probable	2
Sepiadarium kochi	Koch's bottletail squid	n/a	Probable	2, 3
Sepioteuthis lessoniana	Bigfin reef squid	n/a	Probable	2
Taningia danae	Dana octopus squid	n/a	Probable	2
Thysanoteuthis rhombus	Diamondback squid	n/a	Probable	2
Uroteuthis chinensis [recorded as *Loligo chinensis*]	Mitre squid	n/a	Probable	2, 10
Uroteuthis duvaucelii [recorded as *Loligo duvauceli*]	Indian squid	n/a	Confirmed	2, 4, 8, 10
Uroteuthis edulis [recorded as *Loligo edulis*]	Swordtip squid	n/a	Probable	2, 10
Uroteuthis singhalensis [recorded as *Loligo singhalensis*]	Long barrel squid	n/a	Confirmed	2, 8, 10
Order Sepiida: Cuttlefish				
Sepia aculeata	Needle cuttlefish	DD	Confirmed	2, 4, 8
Sepia brevimana	Shortclub cuttlefish	DD	Probable	2, 3, 8
Sepia esculenta	Golden cuttlefish	DD	Unlikely	2, 9
Sepia kobiensis	Kobi cuttlefish	DD	Probable	2, 3
Sepia latimanus	Broadclub cuttlefish	DD	Probable	2, 3
Sepia lycidas	Kisslip cuttlefish	DD	Probable	2, 3
Sepia pharaonis	Pharaoh cuttlefish	DD	Confirmed	2, 4, 7, 8, 11
Sepia recurvirostra	Curvespine cuttlefish	DD	Probable	2, 3
*Sepia savigny*i	Broadback cuttlefish	DD	Unlikely	2, 4
Sepia stellifera	Starry cuttlefish	DD	Probable	2, 3
Sepiella inermis	Spineless cuttlefish	DD	Confirmed	2, 8
Order Octopoda: Octopuses				

Amphioctopus aegina [recorded as *Octous aegina*]	Sandbird octopus	n/a	Probable	2, 5, 10
Amphioctopus neglectus	Octopus neglectus	n/a	Probable	2, 6
Octopus globosus	Globe octopus	n/a	Confirmed	4
Octopus rugosus	Common octopus	n/a	Probable	5
Octopus vulgaris	Common octopus	n/a	Confirmed	2
Order Nautilida: Nautiluses				
Nautilus pompilius	Nautilius	n/a	Possible	1

***Citations**			
1	De Angelis, 2012	7	Su Su Khin, 1992
2	Food and Agriculture Organization, Web page-b	8	Thin Thin Maw, 2009
3	IUCN, Web page	9	Wai Wai Kan Oo, 1982
4	Jar San, 2011	10	World Register of Marine Species, Web page
5	OBIS, *Web p*age	11	This study
6	Sreeja *et al.*, 2012		

APPENDIX 13. BIVALVES OF MYANMAR

Scientific Name	Common Name	IUCN	CITES	Occurrence	*Citation(s)	Habitat
Mussels						
Neosolen aquaedulcioris		LC	n/a	Probable	7	Marine and freshwater
Perna viridis [also recorded as *Mytilus viridis]*	Green mussel	n/a	n/a	Confirmed	2, 8, 28	Marine
Polymesoda bengalensis	Bengali geloina	LC	n/a	Probable	7	Brackish water
Scaphula deltae		LC	n/a	Probable	7	Marine and freshwater
Oysters						
Crassostrea belcheri	Lugubrious cupped oyster	n/a	n/a	Confirmed	3, 4, 5, 12, 13, 20	Marine
Crassostrea rhizophorae	Mangrove oyster	n/a	n/a	Confirmed	13	Marine
Pinctada imbricata fucata	Akoya pearl oyster	n/a	n/a	Confirmed	22, 23, 24, 25, 26	Marine
Pinctada margaritifera	Black-lip oyster	n/a	n/a	Confirmed	21, 26	Marine
Pinctada maxima	White-lip oyster	n/a	n/a	Confirmed	9, 10, 14, 17, 26, 27	Marine
Pteria penguin	Winged pearl oyster	n/a	n/a	Confirmed	11	Marine
Saccostrea cucullata	Hooded oyster	n/a	n/a	Confirmed	3, 4, 6, 13, 15, 20	Marine
Clams						
Acila divaricata		n/a	n/a	Confirmed	19	Marine
Geloina expansa [recorded as *Polymesoda expansa*]	Marsh clam	LC	n/a	Confirmed	18, 28	Mangroves
Hippopus hippopus	Bear paw clam	LC	II	Probable	1, 7	Marine
Sunetta meroe		n/a	n/a	Confirmed	16	Marine
Sunetta subquadrata		n/a	n/a	Confirmed	16	Marine
Tridacna gigas	Giant clam	VU	II	Probable	1, 7	Marine
Tridacna maxima	Small giant clam	LC	II	Confirmed	16	Marine
Tridacna squamosa	Fluted giant clam	LC	II	Confirmed	16	Marine

APPENDIX 14. MARINE GASTROPODS OF MYANMAR

Scientific Name	Common Name	Occurrence	*Citation(s)
Snails			
Anachis spp.		Confirmed	3
Architectonica maxima	Giant sundial	Confirmed	2
Atys spp.	Bubble snails	Confirmed	3
Babylonia spp.	Babylonia snails	Confirmed	3
Babylonia areolata	Maculated ivory whelk	Confirmed	2
Bulla spp.	Bubble snails	Confirmed	4
Canarium urceus [recorded as *Strombus urceus*]	Little pitcher conch	Probable	2
Cassidula spp.		Confirmed	4
Cassis cornuta	Horned helmet	Confirmed	2
Cellana rota	Rayed limpet	Confirmed	2
Cerithidea cingulata	Girdled horn shell	Confirmed	2
Cerithidea fluviatilis		Confirmed	5, 6
Chicoreus brunneus	Adusta murex	Confirmed	5
Chicoreus ramosus	Ramose murex	Confirmed	2, 7
Chicoreus torrefactus	Firebrand murex	Confirmed	2
Chromodoris geminus	Twin chromodoris	Confirmed	7
Conomurex luhuanus [recorded as *Strombus luhuanus*]	Strawberry conch	Possible	2
Conus spp.	Cone shells	Confirmed	4
Conus litteratus	Lettered cone	Confirmed	2
Conus suratensis	Suratan cone	Confirmed	2
Cryptospira ventricosa [recorded as *Marginella ventricosa*]		Probable	2
Cymatium spp.	Triton shell	Confirmed	2
Cypraea eglantina	Eglamtine cowrie	Confirmed	2
Cypraea mauritiana	Humpback cowrie	Confirmed	2
Cypraea talpa	Mole cowrie	Confirmed	2
Cypraea tigris	Tiger cowrie	Confirmed	2
Cypraea vitellus	Pacific deer cowrie	Confirmed	2
Dolomena variabilis [recorded as *Strombus variabilis*]	Variable conch	Confirmed	2
Drupa spp.	Rock snails	Confirmed	4
Elaeocyma spp.		Confirmed	4
Ellobium spp.		Confirmed	4
Ellobium aurismidae	Midas's ear shell	Confirmed	2
Engina spp.		Confirmed	4
Ficus subintermedia	Underlined fig shell	Confirmed	2
Fusinus colus	Distaff spindle	Confirmed	2

Harpago chiragra [also recorded as *Lambis chiraga chiraga*]	Chiagra spider conch	Confirmed	2, 5
Hypselodoris maculosa	Spotted hypselodoris	Confirmed	7
Laevistrombus canarium [recorded as *Strombus canarium*]	Dog conch	Confirmed	2
Lambis lambis	Spider conch	Confirmed	2, 3
Lora spp.		Confirmed	4
Magilus spp.	Murex snails	Confirmed	4
Mancinella spp.	Rock snails	Confirmed	4
Melo spp.	Volutes	Confirmed	4
Melo melo	Indian volute	Confirmed	2
Mitra spp.	Miter shells	Confirmed	4
Morula spp.	Rock snails	Confirmed	4
Murex spp.	Rock snails	Confirmed	4
Murex ternispina	Black spined murex	Confirmed	2
Myurella spp.	Auger snails	Confirmed	4
Myurella kilburni [recorded as *Terebra areolata*]	Fly spotted auger	Confirmed	2
Nassarius spp.	Nassa mud snails	Confirmed	4
Nassarius dorsatus	Channeled nassa	Probable	2
Natica lineata	Lined moon snail	Probable	2
Natica vitellus	Calf moon snail	Probable	2
Nerita albicilla	Oxpalate nerite	Confirmed	2
Nerita chamaeleon	Chamelon nerite	Confirmed	2
Nerita costata	Costate nerite	Confirmed	2
Nerita polita	Polished nerite	Confirmed	2
Nudibranchs			
Oliva miniacea	Redmouth olive	Confirmed	
Oliva spp.	Olive shells	Confirmed	4
Phos spp.		Confirmed	4
Phyllidia varicosa	Swollen phyllidia	Confirmed	7
Phyllidiella pustulosa	Pimpled phyllidiella	Confirmed	7
Pleuroploca spp.	Tulip shells	Confirmed	4
Pleuroplaea trapezium	Rapizium horse		2
Polinices mammilla	Pear shaped moon snail		2
Pugilina cochlidium	Spiral melongena		2
Pugilina spp.	Crown conchs	Confirmed	4
Purpura spp.	Rock snails	Confirmed	4
Pythia spp.		Confirmed	4
Rapana spp	Rock snails	Confirmed	4
Rhinoclavis vertagus	Common vertagus		2
Risbecia pulchella	Beautiful risbecia	Confirmed	7
Tectus niloticus [recorded as *Trochus niloticus* and *T. maximus]*	Trochus shell	Confirmed	1, 2

Tectus pyramis	Pyramid top	Confirmed	2
Terebra spp.	Auger snails	Confirmed	4
Thais spp.	Rock shells	Confirmed	4
Thais alouina	Alou rock shell		2
Tonna dolium	Spotted tun		2
Tonna olearium	Oily tun		2
Turbo argyrostomus	Silvermouth turban		2
Turbo marmoratus	Green turban		2
Turricula spp.		Confirmed	4
Turris spp.	Turrids	Confirmed	4
Turritella duplicate	Duplicate turret		2
Turritella terebra	Screw turret		2
Xenophora solaris	Sunburst carrier	Possible	2
Zierliana spp.		Confirmed	4

***Citations**	
1	Hla Hla Aye, 1996
2	Isituto Oikos, 2011
3	Mya Mya Htwe, 1995
4	Naung Naung Oo, 2012
5	Soe Soe Aye, 2009
6	Thanda Win, 2011
7	This study

APPENDIX 15. SEA CUCUMBERS OF MYANMAR

Scientific Name	Common Name	IUCN	Occurrence	*Citation(s)	**Commercial Value
Acaudina molpadioides		n/a	Confirmed	3	High
Actinopyga echinites	Deep water redfish	VU	Confirmed	3	High
Actinopyga lecanora	Stonefish	DD	Confirmed	3, 4, 5, 6	High
Actinopyga mauritiana	Surf redfish	VU	Confirmed	3	Low
Actinopyga miliaris	Blackfish	VU	Confirmed	4, 6	Not evaluated
Bohadschia argus	Leopardfish	LC	Confirmed	1, 3, 4, 6	Low
Bohadschia atra	Tigerfish	DD	Possible	3	Low
Bohadschia marmorata	Chalky cucumber	DD	Confirmed	3	Low
Bohadschia vitiensis	Brown sandfish	DD	Confirmed	3, 6	Medium
Holothuria (Halodeima) atra	Lollyfish	LC	Confirmed	1, 3, 4, 5, 6	Low
Holothuria (Halodeima) edulis	Pinkfish	LC	Confirmed	3, 5	Low
Holothuria (Lessonothuria) pardalis	Dragonfish	LC	Confirmed	2, 3, 5, 6	Low
Holothuria (Lessonothuria) pardalis		LC	Confirmed	3	Low
Holothuria (Mertensiothuria) hilla		LC	Confirmed	3, 5	Low
Holothuria (Mertensiothuria) leucospilota [also recorded as *H. vagabunda*]	White thread fish	LC	Confirmed	1, 3, 6, 7	Low
Holothuria (Metriatyla) lessoni	Golden sandfish	EN	Confirmed	3	High
Holothuria (Metriatyla) scabra	Sandfish	EN	Confirmed	2, 4, 8	High
Holothuria (Microthele) fuscogilva	White teatfish	VU	Confirmed	5, 6, 8	Low
Holothuria (Microthele) nobilis	Black teatfish	EN	Possible	5	Not evaluated
Holothuria (Selenkothuria) erinaceus [recorded as *H. andersoni*]		n/a	Confirmed	1, 7	Not evaluated
Holothuria (Selenkothuria) moebii		LC	Confirmed	2	Not evaluated
Holothuria (Stauropora) fuscocinerea		LC	Confirmed	2, 4	Low
Holothuria (Theelothuria) spinifera		DD	Confirmed	4	High
Holothuria (Thymiosycia) impatiens	Bottleneck sea cucumber	DD	Confirmed	2, 4	Low
Opheodesoma spp.		n/a	Possible	2	Not evaluated
Pearsonothuria graeffei	Blackspotted sea cucumber	LC	Confirmed	2, 4, 8	Low

Polycheira rufescens [recorded as *Chiridota rufescens*]		n/a	Confirmed	1, 7	Not evaluated
Protankyra spp.		n/a	Possible	2	Not evaluated
Stichopus chloronotus	Greenfish	LC	Confirmed	2, 4, 5, 6, 8	High
Stichopus herrmanni	Curryfish	VU	Confirmed	2, 4, 8	High
Stichopus horrens [recorded as *Stichopus variegatus*]	Selenka's sea cucumber	DD	Confirmed	2, 4, 5, 6, 7	High
Stichopus naso		LC	Confirmed	2, 4	Low
Stichopus ocellatus	Eye-spotted sea cucumber	DD	Possible	8	Not evaluated
Stichopus vastus	Curryfish	LC	Confirmed	2, 4, 8	Low
Stolus buccalis [recorded as *Thyone sacellus*]		n/a	Confirmed	1, 7	Not evaluated
Synaptula sp.	Whitefish	n/a	Confirmed	1, 2, 4	Low
Thelenota ananas	Prickly redfish	EN	Confirmed	4, 5, 6	Medium
Thelenota anax	Amberfish	DD	Confirmed	5	Not evaluated
				**(Nang Mya Han, 2012)	

***Citations**	
1	Duncan *et al.*, 1889a
2	Isituto Oikos, 2011
3	Khin Htwe Yee, 2007
4	Nang Mya Han, 2012
5	National Biodiversity Strategy and Action Plan, 2011
6	Yee Yee Htwe, 2009
7	World Register of Marine Species, Web page
8	This study

APPENDIX 16. ECHINODERMS OF MYANMAR (EXCEPT SEA CUCUMBERS)

Scientific Name	Common Name	Occurrence	*Citation(s)
Class Asteroidea: Sea stars			
Acanthaster planci	Crown-of-thorns starfish	Confirmed	4
Anthenea pentagonula [recorded as *Goniodiscus articulatus*]		Probable	1, 3
Aquilonastra cepheus [recorded as *Asterina cepheus*]		Probable	1, 3
Archaster typicus		Confirmed	1
Astropecten andersoni		Possible	1
Astropecten euryacanthus		Confirmed	2
Astropecten hemprichi		Confirmed	1
Astropecten monacanthus [recorded as *A. notograptus*]		Confirmed	1, 3
Culcita novaeguineae	Cushion star	Confirmed	3
Fromia monilis	Peppermint sea star	Confirmed	3
Linckia guildingi	Guilding's sea star	Confirmed	3
Linckia laevigata	Blue sea star	Confirmed	3
Luidia hardwicki [recorded as *L. forficifer*]		Possible	1, 3
Luidia maculata		Confirmed	1
Nepanthia belcheri [recorded as *N. suffarcinata*]		Probable	1, 3
Pentaceraster gracilis		Probable	2
Class Echinoidea: Sea urchins and sand dollars			
Arachnoides placenta		Confirmed	2
Diadema savignyi		Confirmed	2
Diadema setosum	Black longspine sea urchin	Confirmed	4
Jacksonaster depressum [recorded as *Laganum depressum*]		Confirmed	1, 3
Salmaciella dussumieri		Confirmed	1
Salmacis bicolor		Confirmed	1
Salmacis sphaeroides [recorded as *S. sulcata*]		Possible	1, 3
Stomopneustes variolaris		Confirmed	2
Temnopleurus toreumaticus		Confirmed	1

*Citations	
1	Duncan *et al.*, 1889b
2	Yee Yee Htwe, 2009
3	World Register of Marine Species, Web page
4	This study

APPENDIX 17. SEAWEEDS OF MYANMAR

Scientific Name	Citations
Green Algae	
Acetabularia caliculus	Soe Pa Pa Kyaw *et al.*, 2009c
Anadyomene stellata	Isituto Oikos, 2011
Avrainvillea spp.	Mya Kyawt Wai *et al.*, 2009b; Soe Pa Pa Kyaw *et al.*, 2009c
Avrainvillea erecta	Isituto Oikos, 2011; Mya Kyawt Wai *et al.*, 2009b
Avrainvillea lacerata	Mya Kyawt Wai *et al.*, 2009b; Soe Pa Pa Kyaw *et al.*, 2009c
Boergesenia forbesii	Isituto Oikos, 2011
Boodlea composita	Isituto Oikos, 2011
Caulerpa fergusonii	Mya Kyawt Wai *et al.*, 2009a
Caulerpa lentillifera	Soe Pa Pa Kyaw *et al.*, 2009c
Caulerpa microphysa	Soe Pa Pa Kyaw *et al.*, 2009c
Caulerpa racemosa	Isituto Oikos, 2011; Moe Lwin Lwin, 2012; Mya Kyawt Wai *et al.*, 2009a and this study
Caulerpa serrulata	Isituto Oikos, 2011; Moe Lwin Lwin, 2012; Mya Kyawt Wai *et al.*, 2009a; This study
Caulerpa sertularioides	Isituto Oikos, 2011; Moe Lwin Lwin, 2012
Caulerpa taxifolia	Isituto Oikos, 2011
Caulerpa verticillata	Isituto Oikos, 2011
Chaetomorpha spp.	Hla Tint *et al.*, 1984; Sein Moh Moh Khaing, 2012; Soe Pa Pa Kyaw *et al.*, 2009c
Chaetomorpha aerea	Sein Moh Moh Khaing, 2012
Chaetomorpha antennina	Soe Pa Pa Kyaw *et al.*, 2009c
Chaetomorpha gracilis	Isituto Oikos, 2011; Sein Moh Moh Khaing, 2012
Chaetomorpha linum	Sein Moh Moh Khaing, 2012
Cladophora prolifera	Soe Pa Pa Kyaw *et al.*, 2009c
Cladophora rupestris	Sein Moh Moh Khaing, 2012
Cladophora saracenia	Soe Pa Pa Kyaw *et al.*, 2009c
Cladophora vagabunda	Soe Pa Pa Kyaw *et al.*, 2009c
Cladophoropsis membranacea	Chaw Thiri Pyay Phyo Aye, 2012; Sein Moh Moh Khaing, 2012
Codium spp.	Mya Kyawt Wai *et al.*, 2009c
Codium adhaerens	Mya Kyawt Wai *et al.*, 2009c
Codium arabicum	Isituto Oikos, 2011
Codium edule	Isituto Oikos, 2011; Mya Kyawt Wai *et al.*, 2009c
Codium fragile	Mya Kyawt Wai *et al.*, 2009c
Dictyosphaeria cavernosa	Soe Pa Pa Kyaw *et al.*, 2009c
Dunaliella salina	Tint Tun & Thi Thi Lay, 1989
Halimeda discoidea	Isituto Oikos, 2011; Moe Lwin Lwin, 2012; Soe Pa Pa Kyaw *et al.*, 2009c
Halimeda macroloba	Isituto Oikos, 2011
Halimeda opuntia	Isituto Oikos, 2011; Moe Lwin Lwin, 2012
Hydroclathrus clathratus	Mya Kyawt Wai *et al.*, 2009a

Neomeris annulata	Soe Pa Pa Kyaw *et al.*, 2009c
Rhizoclonium grande	Soe Pa Pa Kyaw *et al.*, 2009c
Rhizoclonium riparium	Sein Moh Moh Khaing, 2012; Soe Pa Pa Kyaw *et al.*, 2009c
Trichosolen gracilis	Soe Pa Pa Kyaw *et al.*, 2009c
Trichosolen mucronatus	Soe Pa Pa Kyaw *et al.*, 2009c
Ulva clathrata	Sein Moh Moh Khaing, 2012; Soe Pa Pa Kyaw *et al.*, 2009c
Ulva compressa	Moe Lwin Lwin, 2012; Sein Moh Moh Khaing, 2012; Thandar, 2012
Ulva flexuosa	Sein Moh Moh Khaing, 2012; Soe Pa Pa Kyaw *et al.*, 2009c
Ulva intestinalis	Isituto Oikos, 2011; Moe Lwin Lwin, 2012; Sein Moh Moh Khaing, 2012; Soe Pa Pa Kyaw *et al.*, 2009c
Ulva lactuca	Sein Moh Moh Khaing, 2012
Ulva linza	Sein Moh Moh Khaing, 2012; Soe Pa Pa Kyaw *et al.*, 2009c
Ulva reticulata	Isituto Oikos, 2011
Ulva spp.	Chaw Thiri Pyay Phyo Aye, 2012; Isituto Oikos, 2011; Moe Lwin Lwin, 2012; Sein Moh Moh Khaing, 2012; Soe Pa Pa Kyaw *et al.*, 2009c; Thandar, 2012
Valonia spp.	Chaw Thiri Pyay Phyo Aye, 2012; Hla Tint *et al.*, 1984; Mya Kyawt Wai *et al.*, 2009a
Valonia aegagropila	Mya Kyawt Wai *et al.*, 2009a
Valonia utricularis	Chaw Thiri Pyay Phyo Aye, 2012
Brown Algae	
Canistrocarpus cervicornis	Soe Pa Pa Kyaw *et al.*, 2009e
Chnoospora minima [recorded as *C. fastigiata*]	Soe Htun *et al.*, 2009a; World Register of Marine Species, Web page
Colpomenia spp.	Chaw Thiri Pyay Phyo Aye, 2012; Khin Khin Gyi, 2010; Myint Myint Cho, 2011; Sein Moh Moh Khaing, 2012; Thin Shwe Yee Win, 2010
Colpomenia sinuosa	Chaw Thiri Pyay Phyo Aye, 2012; Khin Khin Gyi, 2010; Sein Moh Moh Khaing, 2012; Thin Shwe Yee Win, 2010
Dictyopteris woodwardia	Soe Pa Pa Kyaw *et al.*, 2009f
Dictyota adnata	Ma Lei Lei Win, 1990; Sein Moh Moh Khaing, 2012; Soe Pa Pa Kyaw, 2008; Soe Pa Pa Kyaw *et al.*, 2009a, b
Dictyota bartayresiana	Isituto Oikos, 2011; Soe Htun *et al.*, 2009a; Soe Pa Pa Kyaw, 2008
Dictyota cervicornis	Soe Pa Pa Kyaw, 2008; Soe Pa Pa Kyaw *et al.*, 2009e
Dictyota cervicornis [recorded as *D. indica*]	Soe Pa Pa Kyaw & Soe Htun, 2008; World Register of Marine Species, Web page
Dictyota dichotoma	Myint Myint Cho, 2011; Soe Htun *et al.*, 2009a; Soe Pa Pa Kyaw, 2008
Dictyota divaricata	Isituto Oikos, 2011; Soe Pa Pa Kyaw, 2008
Dictyota hauckiana [also recorded as *D. atomaria*]	Soe Htun *et al.*, 2009a; Soe Pa Pa Kyaw, 2008; Soe Pa Pa Kyaw & Soe Htun, 2009; World Register of Marine Species, Web page
Dictyota spp.	Ma Lei Lei Win, 1990; Mya Kyawt Wai, 2008; Mya Kyawt Wai & Soe Htun, 2008, 2009; Myint Myint Cho, 2011; Sein Moh Moh Khaing, 2012; Soe Htun *et al.*, 2009a; Soe Pa Pa Kyaw, 2008; Soe Pa Pa Kyaw *et al.*, 2009a, b; Soe Pa Pa Kyaw *et al.*, 2009e, f, g; Soe Pa Pa Kyaw & Soe Htun, 2008, 2009
Feldmannia mitchelliae [recorded as *Hincksia mitchelliae]*	Soe Htun *et al.*, 2009a; World Register of Marine Species, Web page
Lobophora variegata	Isituto Oikos, 2011; Soe Htun *et al.*, 2009a
Neoralfsia expansa	Soe Htun *et al.*, 2009a

Padina spp.	Chaw Thiri Pyay Phyo Aye, 2012; Isituto Oikos, 2011; Mya Kyawt Wai, 2008; Mya Kyawt Wai & Soe Htun, 2008, 2009; Myint Myint Cho, 1980, 2011; Soe Htun *et al.*, 2009a
Padina antillarum	Mya Kyawt Wai, 2008; Mya Kyawt Wai & Soe Htun, 2009; Soe Htun *et al.*, 2009a
Padina australis	Isituto Oikos, 2011; Mya Kyawt Wai, 2008
Padina boryana	Chaw Thiri Pyay Phyo Aye, 2012; Mya Kyawt Wai & Soe Htun, 2008
Padina japonica	Mya Kyawt Wai, 2008
Padina minor	Isituto Oikos, 2011; Mya Kyawt Wai, 2008; Soe Htun *et al.*, 2009a
Sargassum spp.	Myint Myint Cho, 1980, 2011; Soe Htun *et al.*, 2009a; Soe Tun, 1984
Sargassum aquifolium [recorded as *S. crassifolium*]	Myint Myint Cho, 1980; World Register of Marine Species, Web page
Sargassum ilicifolium [recorded as *S. cristaefolium*]	Myint Myint Cho, 2011; World Register of Marine Species, Web page
Sargassum polycystum	Isituto Oikos, 2011; Myint Myint Cho, 1980; Soe Htun *et al.*, 2009a
Sargassum stolonifolium	Isituto Oikos, 2011; Soe Htun *et al.*, 2009a
Sargassum swartzii	Myint Myint Cho, 2011
Stoechospermum polypodioides [also recorded as *S. marginatum*]	Myint Myint Cho, 1980; Soe Pa Pa Kyaw *et al.*, 2009g; World Register of Marine Species, Web page
Turbinaria ornata	Isituto Oikos, 2011; Mya Kyawt Wai *et al.*, 2009a; Myint Myint Cho, 1980
Red Algae	
Acanthophora spicifera	Chaw Thiri Pyay Phyo Aye, 2012; Hla Tint *et al.*, 1984; Isituto Oikos, 2011; Myint Myint Cho & Thida Nyunt, 2009; Sein Moh Moh Khaing, 2012; Su Su Htwe, 2010; War War Shwe, 2010
Acrochaetium robustum	Soe Htun *et al.*, 2009d
Actinotrichia fragilis	Isituto Oikos, 2011
Amphiroa foliacea	Soe Htun *et al.*, 2009d
Amphiroa fragilissima	Isituto Oikos, 2011
Antithamnion antillarum	Soe Htun *et al.*, 2009e; Soe Htun *et al.*, 2009g
Bangia atropurpurea [recorded as *Bangiadulcis atropurpurea*]	Soe Htun *et al.*, 2009d; World Register of Marine Species, Web page
Bostrychia calliptera [recorded as *B. pinnata*]	Sein Moh Moh Khaing, 2012; World Register of Marine Species, Web page
Bostrychia radicans	Sein Moh Moh Khaing, 2012
Bostrychia tenella [also recorded at *B. binderi*]	Isituto Oikos, 2011; Sein Moh Moh Khaing, 2012; Soe Htun *et al.*, 2009e; Soe Htun *et al.*, 2009g; World Register of Marine Species, Web page
Botryocladia botryoides	Soe Htun *et al.*, 2009e; Soe Htun *et al.*, 2009g
Caloglossa spp.	Cho Cho Latt, 2011; Sein Moh Moh Khaing, 2012; Thandar Soe, 2012
Caloglossa adhaerens	Cho Cho Latt, 2011; Mya Kyawt Wai *et al.*, 2009c; Sein Moh Moh Khaing, 2012
Caloglossa beccarii	Cho Cho Latt, 2011; Sein Moh Moh Khaing, 2012
Caloglossa continua	Cho Cho Latt, 2011; Sein Moh Moh Khaing, 2012
Caloglossa leprieurii	Cho Cho Latt, 2011; Sein Moh Moh Khaing, 2012
Caloglossa stipitata	Cho Cho Latt, 2011; Sein Moh Moh Khaing, 2012
Caloglossa vieillardii	Sein Moh Moh Khaing, 2012

Catenella spp.	Aung Myint, 1980; Ma Myint Than, 1982; Myint Myint Cho & Thida Nyunt, 2009; Sein Moh Moh Khaing, 2012; Soe Htun *et al.*, 1984; Thandar, 2012; Thandar Soe, 2012; Wint Thuzar Nwe, 2010
Catenella impudica	Ma Myint Than, 1982; Sein Moh Moh Khaing, 2012
Catenella nipae	Aung Myint, 1980; Isituto Oikos, 2011; Ma Myint Than, 1982; Myint Myint Cho & Thida Nyunt, 2009; Sein Moh Moh Khaing, 2012; Soe Htun *et al.*, 1984; Thandar, 2012; Wint Thuzar Nwe, 2010
Centroceras clavulatum	Isituto Oikos, 2011
Ceratodictyon repens [recorded as *Gelidiopsis repens*]	Soe Htun *et al.*, 2009e; Soe Htun *et al.*, 2009g; World Register of Marine Species, Web page
Champia parvula	Soe Htun *et al.*, 2009g
Chroodactylon ornatum [recorded as *Asterocytis ornata*]	Isituto Oikos, 2011; Soe Htun *et al.*, 2009d; World Register of Marine Species, Web page
Crouania attenuata	Soe Htun *et al.*, 2009e; Soe Htun *et al.*, 2009g
Dasya flagellifera [recorded as D. flagelliformis]	Soe Htun *et al.*, 2009e; Soe Htun *et al.*, 2009g
Dichotomaria marginata	Isituto Oikos, 2011
Dichotomaria obtusata	Isituto Oikos, 2011
Dichotomaria spathulata [recorded as *Galaxaura arborea*]	Su Su Htwe, 2010; World Register of Marine Species, Web page
Endosiphonia horrida [recorded as *Endosiphonia clavigera*]	Isituto Oikos, 2011; World Register of Marine Species, Web page
Erythrocladia irregularis	Soe Htun *et al.*, 2009d
Erythrotrichia carnea	Soe Htun *et al.*, 2009d
Galaxaura filamentosa	Isituto Oikos, 2011; Su Su Htwe, 2010
Galaxaura rugosa	Isituto Oikos, 2011
Ganonema farinosum [recorded as *Liagora farinosa*]	World Register of Marine Species, Web page; Yin Yin Htay, 2008
Gelidiella acerosa	Isituto Oikos, 2011; Su Su Htwe, 2010
Gelidium arenarium	Isituto Oikos, 2011; Phu Pwint Zin, 2012; Sein Moh Moh Khaing, 2012
Gelidium crinale var. perpusillum	Phu Pwint Zin, 2012; Sein Moh Moh Khaing, 2012
Gelidium pusillum	Soe Htun *et al.*, 2009d
Gracilaria canaliculata	Isituto Oikos, 2011; Sein Moh Moh Khaing, 2012; Soe Pa Pa Kyaw *et al.*, 2009d; Su Su Htwe, 2010
Gracilaria canaliculata [recorded as *Gracilaria crassa*]	Chaw Thiri Pyay Phyo Aye, 2012; Hla Tint *et al.*, 1984; Naw Le Le Hnin, 1980; Soe Pa Pa Kyaw *et al.*, 2009d; Toe Toe Aung, 1987
Gracilaria edulis	Hla Tint *et al.*, 1984; Mu Mu Aye, 1982; Naw Le Le Hnin, 1980; Soe Pa Pa Kyaw *et al.*, 2009d
Gracilaria millardetii	Soe Htun *et al.*, 2009e
Gracilariopsis longissima [recorded as *Gracilaria verrucosa*]	Mu Mu Aye, 1982; Sein Moh Moh Khaing, 2012; Soe Pa Pa Kyaw *et al.*, 2009d; World Register of Marine Species, Web page

Grateloupia filicina	Isituto Oikos, 2011; Soe Htun *et al.*, 2009d
Halymenia durvillaea	Mya Kyawt Wai *et al.*, 2009a; Su Su Htwe, 2010
Halymenia durvillei	Mya Kyawt Wai *et al.*, 2009a
Herposiphonia secunda	Soe Htun *et al.*, 2009e; Soe Htun *et al.*, 2009g
Heterosiphonia muelleri [recorded as *H. struthiopenna*]	Soe Htun *et al.*, 2009e; Soe Htun *et al.*, 2009g
Hydrolithon farinosum [reportded as *Fosliella farinosa*]	Soe Htun *et al.*, 2009d; World Register of Marine Species, Web page
Hydrolithon reinboldii	Soe Htun *et al.*, 2009d
Hydropuntia edulis	Mya Kyawt Wai *et al.*, 2009a; Soe Pa Pa Kyaw *et al.*, 2009d; Thandar, 2012
Hydropuntia edulis [recorded as *Gracilaria foliifera*]	Naw Le Le Hnin, 1980; Toe Toe Aung, 1987; World Register of Marine Species, Web page
Hydropuntia eucheumatoides [recorded as *Gracilaria eucheumatoides*]	Isituto Oikos, 2011; World Register of Marine Species, Web page
Hypnea boergesenii	Mya Kyawt Wai *et al.*, 2009a; Naw Le Le Hnin, 1980; Su Su Htwe, 2010
Hypnea japonica	Mya Kyawt Wai *et al.*, 2009a
Hypnea musciformis var. hippuroides [also recorded as *Hypnea hippurioides*]	Isituto Oikos, 2011; Mya Kyawt Wai *et al.*, 2009a; Naw Le Le Hnin, 1980; World Register of Marine Species, Web page
Hypnea pannosa	Isituto Oikos, 2011; Soe Htun *et al.*, 2009e; Soe Htun *et al.*, 2009g
Hypnea saidana	Isituto Oikos, 2011
Hypnea spinella	Soe Htun *et al.*, 2009e; Soe Htun *et al.*, 2009g
Hypnea spp.	Mya Kyawt Wai *et al.*, 2009a; Myint Myint Cho & Thida Nyunt, 2009; Naw Le Le Hnin, 1980; Soe Htun *et al.*, 2009e; Su Su Htwe, 2010; Thandar, 2012
Izziella orientalis [also recorded as *Liagora orientalis*]	World Register of Marine Species, Web page; Yin Yin Htay, 2008; Yin Yin Htay & Soe Htun, 2009
Jania spp.	Hla Tint *et al.*, 1984; Isituto Oikos, 2011
Kappaphycus alvarezii	Htay Aung, 2009; Lay Min Naing, 2012; Myint Myint Cho & Thida Nyunt, 2009
Laurencia spp.	Chaw Thiri Pyay Phyo Aye, 2012; San Tha Tun, 1990; Sein Moh Moh Khaing, 2012; Su Su Htwe, 2010
Laurencia intricata	Sein Moh Moh Khaing, 2012
Liagora spp.	Yin Yin Htay, 2008; Yin Yin Htay & Soe Htun, 2009, 2010
Liagora boergesenii	Yin Yin Htay, 2008; Yin Yin Htay & Soe Htun, 2010
Liagora ceranoides	Yin Yin Htay & Soe Htun, 2010
Lithophyllum okamurae	Soe Htun *et al.*, 2009d
Lophocladia lallemandii	Soe Htun *et al.*, 2009e; Soe Htun *et al.*, 2009g
Martensia fragilis	Isituto Oikos, 2011
Mesophyllum erubescens [also recorded as *Lithothamnion erubescens*]	Soe Htun *et al.*, 2009d; World Register of Marine Species, Web page

Metagoniolithon stelliferum [recorded as *M. stelligerum*]	Soe Htun *et al.*, 2009d; World Register of Marine Species, Web page
Monostroma nitidum [recorded as *Porphyra crispata*]	Soe Htun & Ko Zaw Zaw Pe, 1987; World Register of Marine Species, Web page
Palisada intermedia [recorded as *Chondrophycus intermedius*]	Soe Htun *et al.*, 2009e; Soe Htun *et al.*, 2009g; World Register of Marine Species, Web page
Palisada perforata [recorded as *Chondrophycus papillosa*]	Mya Kyawt Wai *et al.*, 2009a; World Register of Marine Species, Web page
Peyssonnelia rubra	Soe Htun *et al.*, 2009e; Soe Htun *et al.*, 2009g
Phyllophora spp.	Isituto Oikos, 2011
Plocamium cartilagineum	Isituto Oikos, 2011
Polysiphonia spp.	Aung Myint, 1980; Isituto Oikos, 2011; Jar San, 2012; Mu Mu Aye, 1982; Sein Moh Moh Khaing, 2012; Soe Htun *et al.*, 2009e; Soe Htun *et al.*, 2009g
Polysiphonia subtilissima	Isituto Oikos, 2011; Jar San, 2012; Sein Moh Moh Khaing, 2012; Soe Htun *et al.*, 2009e; Soe Htun *et al.*, 2009g
Porphyra spp.	Soe Htun & Ko Zaw Zaw Pe, 1987; Soe Htun *et al.*, 2009d
Portieria hornemannii	Isituto Oikos, 2011
Ptilota gunneri [recorded as *P. plumosa*]	Soe Htun *et al.*, 2009e; Soe Htun *et al.*, 2009g; World Register of Marine Species, Web page
Pyropia suborbiculata [recorded as *Porphyra suborbiculata*]	Soe Htun *et al.*, 2009d; World Register of Marine Species, Web page
Rhodymenia spp.	Isituto Oikos, 2011
Scinaia furcellata	Mya Kyawt Wai *et al.*, 2009a
Stylonema cornu-cervi	Soe Htun *et al.*, 2009d
Titanophora spp.	Mya Kyawt Wai *et al.*, 2009d
Titanophora pikeana	Mya Kyawt Wai *et al.*, 2009d
Tolypiocladia calodictyon	Isituto Oikos, 2011
Tolypiocladia glomerulata	Isituto Oikos, 2011
Vanvoorstia spectabilis	Isituto Oikos, 2011
Yamadaella caenomyce [recorded as *Liagora caeomyce*]	World Register of Marine Species, Web page; Yin Yin Htay, 2008
Wrangelia hainanensis	Isituto Oikos, 2011

APPENDIX 18. DIVE TOURISM SURVEY FINDINGS

Summary

- Many dive tourists entering Myanmar from Thailand are European. It is likely that there will be a growth in Asian and North American tourists in the near future.
- Tourists come to Myanmar to dive because they value the isolation (compared with other locations such as Thailand). They expect to see sharks, rays, big fish, healthy reefs and beautiful landscapes in Myanmar.
- Most of the divers surveyed were experienced divers with 77% at an advanced dive certification level or higher with 69% having already completed more than 101 dives. Their underwater observation skills were likely quite high.
- At dive sites, tourists most highly value seeing big fish, many fish and diverse systems.
- Of Marine animals, they most highly value seeing fish, especially sharks, pelagic fish and reef fish. This is in line with what they were expecting to see in Myanmar. This suggests that tourists likely specifically planned to visit Myanmar because their expectations matched with what they would value experiencing in the country.

In early 2013, sightings of sharks, rays and Marine turtles were rare. These findings are based on observations by 50 divers who conducted a total of 674 dives combined, which is roughly equivalent to 561.7 hours of in-water observations.

- Dive guides who had worked in Myanmar before (n = 11) and returning divers (n = 17) made similar observations on how things were changing in Myanmar:
    - Populations of sharks, large fish and marine turtles are decreasing
    - Increased observations of fishing gear at sites and rubbish
    - Algae on the reefs is increasing
- Most tourists also noticed a number of negative human impacts: trash, blast fishing and abandoned fishing gear. They also noted other dive boats.
- Despite not seeing the sharks they were expecting and hoping to see, most tourists would still recommend Myanmar as a dive location. This is mainly to do with the underwater beauty, still healthy corals and a sense of isolation in a remote area.
- Demand for diving in Myanmar continues to grow; dive operators in Thailand are planning on expanding the number of trips to Myanmar for the 2013/2014 season. This will likely mean that their clients will see many other divers and dive boats in Myanmar and this will affect their clients' sense of isolation. Thai-based dive operators may want to consider more coordination with planning dive schedules to limit overlap and keep their clients satisfied.
- The state of Myanmar's marine resources has already started to decline in terms of their value for dive-based tourism. Efforts to protect and conserve sharks and populations of large fish will be critical for the development of a healthy dive-based tourism industry in Myanmar. And through efforts to limit trash, blast fishing and the abandonment of fishing gear, some aspects of Myanmar's special qualities for tourism (a sense of remoteness and isolation) might be maintained. Improvements in these areas will also help maintain healthy marine resources for the needs of other stakeholders beyond simply tourism.
- Tourism development plans should be made in conjunction with clear marine conservation and management goals in order to maintain health of the ecosystems while providing tourists with the experiences they value.

- Portions of the income currently generated through fees paid by tourists entering Myanmar to dive could be directed toward some targeted marine conservation efforts.

Nationalities

Most of the respondents who were interviewed were either French (23%) or German (21%). This is, in part, because most of the interviews (85%) were guests of the Smiling Seahorse and Aladdin Dive Safari companies which are owned and operated by French and German/Dutch nationals, respectively. These owners are best able to attract customers who use their same language or are of the same culture. A-One Divers, which is Thai-owned, accounted for only 15% of the respondents who were from a wide range of countries. Europeans were, by far, the dominant tourists representing a total of 77% of the tourists interviewed. North Americans accounted for 15% and Asians 8%.

Gender

The sex ratio within both the tourists and dive guides surveyed over this research were almost identical with males the dominating at 73 and 71%, respectively. This is higher but still comparable to the general SCUBA diving population; across 2007 to 2012, the proportion of men earning their Diving Certification through PADI ranged from 66.0 to 67.1% (PADI, 2013).

Age

Tourists included a full range of ages with most (69%) being between 31 and 50 years old. Dive Guides tended to be slightly younger with the majority being between 31 and 40 years old.

Experience

The majority of tourists surveyed have an Advanced dive certification level or higher (77%) and have already completed more than 101 dives (69%). This illustrates that most of those surveyed were experienced divers who likely are aware and observant of marine life plus have experienced a range of dive conditions. Seventeen of the 52 surveyed (33%) had dived in Myanmar before up to four separate trips so their perceptions are of particular interest.

Unsurprisingly, all the dive guides have reached high dive certification levels since this is a requirement for their positions plus they have logged a great number of dives. This level of experience likely reflects an even greater level of observational skills of underwater conditions.

Most of the dive guides the dive guides worked in Thailand before starting to work in Myanmar. Fourteen (82%) had dived in Myanmar over previous seasons with two having worked seven dive seasons in the country and as far back as 2005.

Expectations

Before entering Myanmar, tourists were asked the open-ended question of what they were expecting to see while diving there. Fifty people responded, many with multiple answers. The majority (62%) of people were expecting to see sharks. Other high expectations were to see healthy corals and rays.

What do tourists most value at a dive site?

Tourists were asked to choose and rank the top three things they value at a dive site from a list. They had the option to add additional items but no one surveyed choice to do so. Overwhelmingly tourists said they valued

dive sites that had many fish. They next valued pelagic fish at the sites. Highly diverse sites with healthy corals are also important. They also value a variety of sites, a clean environment and good visibility. Dive guides were asked what they thought tourists most value. They correctly identified that tourists value many fish, pelagic fish and high diversity in the same order, which suggests that the tourists surveyed during this survey period are similar to those that the dive guides have guided in the past. However, overall the guides undervalued the importance of a clean environment and site variety to the tourists they guide.

What animals do tourists most value?

Tourists were also asked to choose and rank the top five organisms they value at a dive site from a list. The top four are presented here. Overwhelmingly tourists valued sharks with 87% of respondents valuing them the most. Pelagic fish were identified by 75% as the second most valued organism to see on a dive. Dive guides also expected this valuation — 100% thought sharks were the most valued and 88% identified pelagic fish as the second most valued. Tourists also valued reef fish, octopuses, rays and marine turtles highly.

What animals did divers see on their trips to Myeik Archipelago in 2013?

The 52 divers surveyed conducted a total of 701 dives over their combined trips (n = 52, mean = 13.5 dives/trip, SD = 1.4). However, two of the 52 tourist divers did not respond to questions on observed species. The remaining 50 divers who did respond conducted a total of 674 dives combined. With each dive conservatively estimated at 50 minutes long, this is equivalent to 561.7 hours of in-water observations.

Of the species of interest to divers, they all saw nudibranchs, moray eels and shrimps at some point on their dive trip. Many also reported seeing Lobsters (98%), Rays (74%) and Octopuses (46%). Many made additional comments that they saw Scorpionfish, a category that wasn't included in the original list of expected, valued target animals. We did not ask specifically about citings of the large priority animal groupings of reef fish and pelagic fish in this question since those categories are very broad and every diver would undoubtedly see them on these trips.

Sharks

Considering that sharks were identified as an animal of primary interest to 87% of all the divers, we can be confident that they made special efforts to look out for them. However, only 16 divers (32%) saw sharks over these dives and reported seeing a total of 24 sharks. This is equivalent to seeing one shark every 28 dives or one shark every 23.4 hours that a diver is in the water ("diver-hours"). Most of the sharks seen were Nurse sharks (*Nebrius ferrugineus*, the Tawny nurse shark) (54%) and the next most common were White-tipped reef sharks (*Triaenodon obesus*) (29%).

Rays

Thirty-seven divers (74%) saw rays over these dives and reported seeing a combined total of 113 rays. This is equivalent to seeing one ray every 6 dives or one shark every 5.0 diver-hours. Many divers reported the species they saw but were not clear on the number of each. Species included the Blue-spotted Stingray (*Neotrygon kuhlii*) and Eagle rays (*Aetobatus ocellatus*). Three divers also reported seeing "Black-spotted stingrays", however there is no clear, common understanding of what species this common name refers to.

Marine turtles

Marine turtles were reported seen by 42% of 50 tourist divers over 674 dives. Two were Hawksbills (*Eretmochelys imbricata*) and 19 were Green sea turtles (*Chelonia mydas*). Twenty-one sightings by these 50 divers are equivalent to one sighting every 31 dives or 25.5 diver-hours.

Octopuses

Octopuses were reported seen by 46% of 50 tourist divers over 674 dives. This is equivalent to one animal every 13.5 dives or 11.2 diver-hours. None of the tourists identified octopuses to species.

Human Impacts

Tourists were asked what of a variety impacts they noticed during their dive trip in Myanmar. Most of the 51 people, unsurprisingly, saw fishing boats at an average of 6.9 boats over the 3-4 day trip. Of concern, though, is that 90% heard or noticed evidence of blast fishing. The tourists reported hearing the blasts underwater and would feel nervous and insecure. Also, 55% provided the additional comment that they saw abandoned fishing nets and gear. This broken and lost gear may continue to ensnare and kill fish and is often called "ghost nets" or "ghost traps".

A majority (69%) noticed coral bleaching. Of the 35 persons that reported on coral colony bleaching numbers, it was reported that they saw, on average, 4.5 bleached colonies each over 13 to 14 dives. That rate is not alarming but additional monitoring should be considered.

Many also noticed human trash (94%) and saw other dive boats (94%) during their trip, which are both things that can impact tourist satisfaction.

Changes over time

Of the 17 dive guides who were surveyed, six did not note any changes on Myanmar reefs; three of these guides were working their first season in Myanmar so could not comment on changes.

Of the 11 guides who noted changes, they all noted that there have been decreases in sharks and large reef fish plus an increase the fishing gear and rubbish at the dive sites. Most (8 to 10) also indicated fewer marine turtles, more algae on the reef (an indicator of poor reef health) and an increase in fishing activities. Fortunately most have not observed elevated levels of coral bleaching or the presence of Crown-of-Thorns starfish (which is an invasive species that consumes coral).

At the end of the dive trip, the 17 tourists who had dived in Myanmar in previous years were asked in an open-ended question what changes they had noticed at the sites since their previous dive trips to Myanmar. Respondents were allowed to provide more than one answer. The tourists noted that there were less fish in general (41%) and less big fish such as sharks (41%) and less rays (12%) compared to previous years. There were single comments on less guitarfish and less turtles. Since divers in Myanmar most highly value seeing sharks and pelagic fish, it is not surprising that the return divers' comments focused on those groups. No comments were given by 29%.

What has changed since you last dived in Myanmar?	#	Percentage
Less fish	7	41%
Less big fish/ Less sharks	7	41%
Less Rays	2	12%
Less guitar fish	1	6%
No turtles	1	6%
No comment given	5	29%

Would you recommend diving in Myanmar?

Of the 50 tourists who responded to the question of whether they would recommend diving in Myanmar, interviewed, 48 (96%) said they would and two (4%) said no or maybe. When asked why, many said they valued the underwater beauty and topography (65%) and the coral communities (31%). They also mentioned the landscape, that there were few other dive boats and they enjoyed their experience with the dive operator. 10% mentioned that they were concerned about the lack of fish and it impacts whether they will return.

Why would you recommend diving in Myanmar?	#	Percentage
Underwater beauty/ Underwater topography	31	65%
Nice corals	15	31%
Nice Landscape (Above water, underwater, or both)	10	21%
Few other dive boats	10	21%
Enjoyable experiences with tourist operation	5	10%
Nice diving, general	3	6%
Variety of sites	1	2%
… but not many fish left	5	10%

Dive Pressure

The dive season in this region typically runs from the beginning of November to the end of April. Over the 2012/2013 dive season, a maximum of 646 diving tourists entered Myanmar from Ranong. During other trips, the companies focused on dive sites in Thailand. Dive shop owners are reporting a rising demand from their clients for more trips to Myanmar. They are planning on increasing their trips to the country for the 2013/2014 dive season.

APPENDIX 19. STAKEHOLDER MEETING — THREATS, ISSUES, AND OPPORTUNITIES

The primary threats, issues and recommendations identified in a stakeholder meeting on 7 June, 2013.

THREATS

1. Overfishing
    a. Illegal, Unregulated and Unreported Fishing (IUU)
    b. Over fishing capacity
    c. Destructive fishing
    d. Malpractice in technology
    e. Over investment in the fisheries sector
2. Undisciplined Tourism
3. Watershed degradation
    a. Sedimentation
    b. Agro toxin
    c. Land based pollution
    d. Waste discharge
    e. Boat based rubbish, jetsam
4. Extraction
    a. Sand mining
    b. Offshore mining
5. Climate Change
    a. Sea Level Rise
    b. Unreliable weather
    c. Addiction to fossil fuels
6. Environmental chain reactions

ISSUES

1. Research
    a. Capacity
        i. Lack of funding
        ii. Insufficient and inadequate essential field and laboratory equipment
        iii. Long and time consuming communication channels and logistics
        iv. Low capacity for research, conservation and local participation
    b. Fields of study
        i. Insufficient and/or lack of data and information for policy makers and action plans
        ii. Need to identify indicator species for environmental and ecological studies
        iii. More long-term ecological studies on specific species
        iv. Need more ecological studies
        v. Develop monitoring programme of water quality (physiochemical parameters)
2. Policies and Laws
    a. Enforcement and compliance
        i. Weak in legal supports and lack of funding for enforcement
        ii. … leading to weak enforcement and lack of compliance with laws and regula-

tions

iii. Relevant laws need updating

b. Clarification

i. Authority over fishing concession between the Union Government and State/Regional governments is not yet clear

ii. Unclear policy of resource management and development plan of Taninthayi regional government

iii. Need clear and thorough comprehension of relevant laws and notifications

3. Community
    a. Poverty
    b. Low awareness
    c. Lack of alternative livelihoods
4. General
    a. Weak collaboration and coordination among stakeholders

RECOMMENDATIONS

1. Overfishing
    a. Over investment in the fisheries sector can be reduced and controlled by establishment of fishery economy structure, development of zoning and sector planning and formulation and creation of alternative investment opportunities
2. Tourism
    a. By issuing rules and regulations, formulation and implementation of pilot project, establishment of model and demonstration site(s) to show economic development and environmental sustainability will control undisciplined tourism
3. Watershed Degradation
    a. Develop proper waterways and watershed management by identification and control of effluent from rivers and silting from soil erosion
    b. Identify sources and control the use of agro toxin in order to mitigate the adverse effect of land based pollution to coastal and marine environment
    c. Identification and control of waste at the source can reduce the waste discharge from both land and boat
4. Research
    a. Investment in research must be encouraged
    b. Local universities and departments at three coasts should take responsibility to conduct broader and intensive research work at their respective coasts
    c. Establish a network among researchers, universities and government agencies to raise awareness
    d. Establish a "Marine and Coastal Resources Research Centre" with biologists and scientists from universities in order to conduct both short term and long term research activities
    e. Upgrade human resource at universities in collaboration and cooperation with international organisations, research centres and overseas universities
    f. Divide big projects and financial support into several phases or in order to speed up and shorten communication channels and to be able to undertake research at lower levels
5. Legal
    a. Practice bonus and penalty system for Illegal, Unreported and Unregulated (IUU) fishing
    b. Establish a Monitoring, Control and Surveillance (MCS) system for fisheries enforcement
    c. Enhance law enforcement through cooperation of multi stake holders
    d. Update relevant laws by reviewing the policy and existing laws first based on research, public participation and other prevailing factors to maintain sustainability

6. Communities
    a. In combination with pride campaign and celebrity campaign, launch training and education programmes for awareness and sustainable use of marine living resources
    b. Develop alternative sources of income
7. Collaborations
    a. Promote coordination and cooperation among researchers, relevant/in line departments, agencies and stakeholders by holding occasional meetings as needed
    b. Collaborate with international fishery organisations for both national and regional
8. General
    a. Environmental Impact Assessments (EIA), Social Impact Assessments (SIA) and Health Impact Assessments (HIA) should be compulsory for all development projects
    b. Rational exploitation of resources with international practices, structure and methodologies should reduce malpractice in technology
9. Climate Change
    a. Develop translatable and quick early warning system for climate change and natural disasters
    b. Prepare a disaster risk map to inform vulnerable areas and to develop appropriate action plans
    c. Promote alternative sources of energy to reduce environmental degradation
    d. Encourage wind turbine and tide turbine installations

APPENDIX 20. STAKEHOLDER MEETING — ATTENDEES

No.	Name	Designation and Organization	Opening Ceremony	Whole Workshop
Taninthayi Regional Government				
1	U Tin Soe	Minister, Forestry and Mining, Taninthayi Regional Government, Dawei	X	
WCS				
2	U Than Myint	Country Director, WCS Myanmar Program, Yangon	X	X
3	U Saw Htun	Deputy Country Director, WCS Myanmar Program, Yangon	X	X
4	U Kyaw Thinn Latt	Landscape Coordinator, WCS Myanmar Program, Yangon	X	X
5	Mr. Robert Tizard	Technical Advisor, WCS Myanmar Program, Yangon	X	X
6	Ms. Katherine Holmes	Associate Conservation Scientist, Global Marine Conservation Program, WCS Global Program, USA	X	X
MSAM				
7	U Tint Tun	Marine Science Association, Myanmar, Yangon	X	X
8	U Tint Wai	Marine Science Association, Myanmar	X	X
9	U Myo Than Naing	Marine Science Association, Myanmar	X	X
Technical				
10	U Hla Win	Deputy Director General (Retired), Department of Fisheries, Yangon	X	X
11	Dr. Swe Thwin	Professor (Retired), Yangon	X	X
Department of Fisheries, Nay Pyi Taw				
12	U Mya Than Tun	Deputy Director, Environment and Endangered Aquatic Animals Conservation Unit, DoF, Nay Pyi Taw	X	X
Department of Fisheries, Taninthayi Region				
13	U San Maung Oo	Township Fishery Officer, Department of Fisheries, Thayetchaung Township	X	X
14	U Soe Thant	Township Fishery Officer, Department of Fisheries, Launglon Township	X	X
15	U Soe Tun Naung Oo	Township Fishery Officer, Department of Fisheries, Myeik Township	X	X
16	U Thein Naing	Township Fishery Officer, Department of Fisheries, Kyunsu Township	X	X
17	U Tun Than	Township Fishery Officer, Department of Fisheries, Palaw Township	X	X
18	U Tin Maung Maung	Township Fishery Officer, Department of Fisheries, Bokebyin Township	X	X
Relevant Departments, Myeik District and Township				
19	U Min Naing	District Officer, Planning Department, Myeik District	X	X

20	U Kyaw Thu	District Officer, Irrigation Department, Myeik District	X	X
21	U Kyaw Oo	Township Officer, Water Resource Department, Myeik Township	X	X
22	U Htay Win	Township Officer, Agricultural Department, Myeik Township		
General Administration, Myeik District and Township				
23	U Lwin Ko Oo	Administrator, General Administration Department, Myeik District	X	X
24	U Thein Win	Administrator, General Administration Department, Myeik Township	X	X
Navy, Taninthayi Coast				
25	Major Htet Htet Tun	Representative, Navy, Kyunsu Township	X	X
26	Captain Win Than	Representative, Navy, Kyunsu Township	X	X
Forest Departments, Taninthayi Region				
27	U Tint Swe	Director, Forest Department, Taninthayi Region	X	X
28	U Tin Maung Lwin	Assistant Director, Forest Department, Myeik District	X	X
29	U Hla Thaung	Staff Officer, Forest Department, Myeik Township	X	X
30	U Win Tun Oo	Staff Officer, Forest Department, Kyunsu Township	X	X
Universities				
31	Dr. Thet Tun Aung	Rector, Myeik University	X	X
32	Dr. Than Tun Oo	Pro-rector, Myeik University	X	X
33	Dr. Nang Mya Han	Professor, Head of Department, Marine Science Department, Myeik University	X	X
34	Dr. Khin Khin Than	Professor, Head of Department, Chemistry Department, Myeik University	X	X
35	Dr. Naw Lar Pwe Phaw	Professor, Head of Department, Zoology Department, Myeik University	X	X
36	Dr. Sanda Hlaing	Professor, Head of Department, Botany Department, Myeik University	X	X
37	Dr. Than Htut Lwin	Professor, Head of Department, Geology Department, Myeik University	X	X
38	Dr. Nant Mu Aye	Professor, Head of Department, Geography Department, Myeik University	X	X
39	Dr. Khin Than Kywe	Professor, Head of Department, Zoology Department, Dawei University	X	X
40	Dr. Khin Maung Cho	Professor, Head of Department, Marine Science Department, Pathein University	X	X
41	Dr. Tint Swe	Professor, Marine Science Department, Mawlamyine University	X	X
42	Dr. San Thar Tun	Professor, Marine Science Department, Myeik University	X	X
43	Dr. Lay Wah	Professor, Botany Department, Dawei University	X	X

© Katherine Holmes/WCS


WILDLIFE
CONSERVATION
SOCIETY
Saving wildlife and wild places
around the globe since 1895.