Republic of Maldives
Ministry of Fisheries and Agriculture

REPUBLIC OF MALDIVES
PROJECT FOR THE FORMULATION OF MASTER PLAN FOR SUSTAINABLE FISHERIES (MASPLAN)

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Final Draft: 7 August 2017

Sustainable Fisheries Development Plan of the Important Sub-sectors in the Maldives 2016 – 2025

– Goals, Objectives and Projects –

Ministry of Fisheries and Agriculture

Republic of the Maldives

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DBS	Diamondback Squid
d-FAD	drifting Fish Aggregating Device
EEZ	Exclusive Economic Zone
EFSIS	European Food Safety and Inspection System
EIA	Environmental Impact Assessment
EPA	Environment Protection Agency
ESMF	Environment Social Management Framework
FAD	Fish Aggregating Device
FAO	Food and Agriculture Organization
FRP	Fiberglass Reinforced Plastic
GDP	Gross Domestic Product
GoM	Government of Maldives
GSM	Global System for Mobile Communications
IFAD	International Fund for Agricultural Development
IOTC	Indian Ocean Tuna Commission
IUU	Illegal, Unreported and Unregulated (fishing)
JICA	Japan International Cooperation Agency
MASPLAN	Project for the Formulation of Master Plan for Sustainable Fisheries in the Republic of Maldives
MCS	Monitoring Control and Surveillance
MDG	Millennium Development Goal
MED	Ministry of Economic Development
MEDeP	Mariculture Enterprise Development Project
MEE	Ministry of Environment and Energy
MIFCO	Maldives Industrial Fisheries Company Ltd.
MNDF	Maldives National Defence Force
MoFA	Ministry of Fisheries and Agriculture
MoT	Ministry of Tourism
MPA	Marine Protected Area
MPS	Maldives Police Service
MRC	Marine Research Centre
MSC	Marine Stewardship Council
MTDF	Mariculture Training and Development Facility (in Maniyafushi)
NACA	Network of Aquaculture Centres in Asia-Pacific
NGO	Non Governmental Organization
nm	nautical mile
PP	Pilot Project
PV	Post-harvest and Value addition
RF	Reef Fisheries
RSW	Refrigerated Sea Water
SAP	Strategic Action Plan
SEA	Strategic Environmental Assessment
SEAFDEC	Southeast Asian Fisheries Development Centre
SFDPIS	Sustainable Fisheries Development Plan of the Important Sub-Sectors
SIDS	Small Island Developing State
SME	Small and Medium Enterprise
SPDC	Sector Plan Drafting Committee
SWOT	Strengths, Weaknesses, Opportunities and Threats
SSWG	Sub-Sector Working Group
TA	Technical Assistance
UNCLOS	United Nations Convention on Law of the Sea
VMS	Vessel Monitoring System
WBG	World Bank Group

FOREWORD

The vast Exclusive Economic Zone (EEZ) of the Maldives has rich fishing grounds and for time immemorial, the fisheries sector has been the backbone of the country's economy, providing livelihood and foreign exchange. Maldivians have always coexisted with the marine ecosystems and are renowned for their sustainable and environmental friendly methods of fishing.

For the fisheries sector to stimulate growth and modernize, it needed a long-term strategy with a coherent approach integrating resources, environment, livelihoods and socio-economic aspects. To that effect, the Government of Maldives requested technical assistance from the Japan International Cooperation Agency (JICA) for the elaboration of the "Sustainable Fisheries Development Plan of the Important Sub-sectors in the Maldives 2016-2025" (SFDPIS). MoFA gratefully appreciates this technical cooperation.

The overriding objective of the SFDPIS is to provide the Ministry of Fisheries and Aquaculture with the framework to fulfil its overall mandate, i.e. "to manage and develop all marine living resources in the maritime zones of the Maldives in a sustainable manner". The Plan is built on the vision, policy objectives and strategies for the fisheries sector as set out in the current Strategic Action Plan (SAP) of MoFA. It seeks to guide the industry's development over the next decade by implementing targeted projects and activities.

A sub-sector approach was adopted: 4 sub-sectors, i.e. oceanic fisheries, reef fisheries, aquaculture and post-harvest and value addition, were defined on the basis of the main activities of the fisheries sector.

SFDPIS has been prepared through a consultative process, coordinated by professional staff of MoFA and with the support of international consultants. Various stakeholders including relevant government institutions, fishers, fish processors, fish traders etc. were intensely involved in the Plan formulation.

The Joint Coordinating Committee (JCC) that represented relevant government institutions provided the Sector Plan Drafting Committee (SPDC) with guidance and direction throughout the process. The SPDC provided valuable insights and it is noteworthy that members of this Committee dedicated a lot of time and efforts towards the completion of the Plan. The work of both JCC and SPDC deserves our gratitude. MoFA also thanks most sincerely the tireless commitment of the MoFA drafting team and the JICA experts involved in the formulation of the SFDPIS.

With the "Sustainable Fisheries Development Plan of the Important Sub-sectors in the Maldives 2016 – 2025", all stakeholders have now at their disposal a precious guiding instrument to support their endeavor towards the sustainable development of the fisheries sector.

Dr. Mohamed Shainee

Minister of Fisheries and Agriculture

EXECUTIVE SUMMARY

The Republic of Maldives is situated in the Indian Ocean, south west of the Indian subcontinent. It has one of the largest coral reef ecosystems in the world, with 26 natural atolls grouping 1,190 coral islands. The total population of the country is estimated to be around 400,000. Despite a dispersed population, the Maldives has recently achieved notable development: it has sustained an average growth rate of 6% for the past two decades; it has achieved five out of the eight Millennium Development Goals (MDGs) ahead of the 2015 deadline, making it South Asia's only "MDG+" country.

Tourism and fisheries are the main sectors of the economy and the main sources of foreign exchange earnings; they directly contribute to about 40 percent of the country's GDP and account for almost half of the national employment.

Close to 90% of the total marine harvest in the Maldives comprise of tuna and tuna-related species. Over the past two decades, the total annual fish catch increased steadily and peaked in 2005-2006 at around 180,000 tons; in 2015 it was estimated at 120,000 tons. As in the case of tuna, the catch from reef fisheries has grown substantially over the past two decades, linked to the expansion of tourism and new opportunities in international market, the growth in recreational fishing and an increasing demand for reef fish for local consumption. Aquaculture is still at its infancy in the country, even though development of this sub-sector has been a priority area of the Government for a number of years. Worth about US$ 160 million annually, fish and fishery products represent over 95% of the total export value of the Maldives. The country became a full member of the Indian Ocean Tuna Commission (IOTC) in July 2011 and since then has played a very active role in promoting sustainable exploitation of resources in the region. The skipjack fishery is MSC-certified.

Developing the fisheries sector is a priority for the Government of Maldives (GoM). A new Fisheries Act is under preparation and the Ministry of Fisheries and Agriculture (MoFA) has formulated a Strategic Action Plan (SAP) – 2014-2018 for the sector; to assist MoFA in implementing this SAP and to overcome challenges currently faced by the sector, GoM requested technical assistance from the Japan International Cooperation Agency (JICA) for the design of a "Sustainable Fisheries Development Plan of the Important Sub-Sectors in the Maldives" (SFDPIS). A sub-sector approach was adopted to formulate this Plan; 4 sub-sectors, i.e. oceanic fisheries, reef fisheries, aquaculture and post-harvest and value addition, were defined on the basis of the main activities of the fisheries sector.

Two major partners are currently involved in the fisheries sector development, the International Fund for Agricultural Development (IFAD) and the World Bank Group (WBG). Two projects they co-finance are currently under implementation and will be instrumental for the implementation of the SFDPIS.

The Plan is based on the following guiding principles: i) it supports the implementation of the SAP, ii) it encourages stakeholder involvement, iii) it promotes community development, iv) it enhances human resource development, v) it enhances partnership with other sectors, vi) it gives due consideration to environment protection and vii) it promotes gender equality.

During the preparation process of the Plan, a Strengths, Weaknesses, Opportunities and Threats (SWOT) analysis was carried out for each sub-sector and was refined through a problem/objective analysis. As a result, the overall picture of the fisheries sector clearly shows that in spite of a number of weaknesses and threats, the sector enjoys considerable strengths and could benefit from existing opportunities. The purpose of the Plan is to build on these strengths and opportunities and simultaneously, address the weaknesses and mitigate the threats. The SFDPIS encompasses a comprehensive series of components, i.e. fisheries resource management, technological development,

training and awareness, public services, legal and institutional framework and financial system.

The **overall goal** of the SFDPIS is to provide the Ministry in charge of the sector with the framework to fulfil its overall mandate, i.e. "to manage and develop all marine living resources in the maritime zones of the Maldives in a sustainable manner".

The **goals and sub-goals** of the SFDPIS correspond to the objectives to be reached through the resolution of the core issue and its main causes identified for each sub-sector. An **approach** is the way through which a given sub-goal of a sub-sector is achieved; it encompasses a set of projects to be implemented to that effect.

Goals, sub-goals / approaches and priority projects for each sub-sector are as follows:

For Oceanic Fisheries, the goal is: "The opportunities to benefit from the oceanic fisheries resources are fully taken advantage of". The sub-goals / approaches and respective priority projects are as follows:

- Strengthening of fisheries management, with the projects i) Improvement of MCS system, ii) Training on resource management, and iii) Review and implementation of bait fish management plan.
- Technological development of tuna fisheries, with the projects i) Extension of improved livebait stocking system in pole-and-line fishery and ii) Development of new masdhoni design.
- Development of new oceanic fisheries, with the project i) Development of new deep sea fisheries (Diamondback Squid and other fishes and ii) Promotion of private investment.
- Improvement of public service to fishers, with the project Establishment of Fisher's Marinas.

For Reef Fisheries, the goal is: "The reef resources are exploited in an ecologically and economically sound manner". The sub-goals / approaches and respective priority projects are as follows:

- Strengthening of reef fisheries management, with the projects i) Improvement of biological, socio-economic and statistical data collection and analysis system, ii) Improvement of relevant legislation about reef fisheries, iii) Enhancement of fisheries compliance/ enforcement, iv) Design and implementation of reef fisheries management plans and v) Capacity enhancement on fishery resource management.
- Technological development of reef fisheries, with the projects i) Improvement of boat design and equipment for reef fishery and ii) Awareness on fishing and fish handling techniques in reef fishery.
- Improvement of public service to fishers, with the projects i) Establishment of Fisher's Marinas and ii) Strengthening the capacity of ice making facilities.

For Aquaculture, the goal is: "The aquaculture industry is fully developed in the Maldives". The sub-goals/approaches and respective priority projects are as follows:

- Aquaculture technological development, with the projects i) Establishment of multi-species hatchery, ii) Establishment of milkfish seed production facilities to provide bait, iii) Development of domestic fish feed using by-product of fish processing, iv) Refinement of existing aquaculture techniques and v) Training and demonstration capacity building of MTDF/MRC.
- Aquaculture technical extension, with the projects i) Extension of potential mariculture techniques and ii) Promotion of aquaculture through formal education system.

- Management of aquaculture sub-sector, with the projects i) Improvement of aquatic animal health management and ii) Strengthening institutional mechanism on aquaculture activities.
- Establishing a financing system, with the project Development of a financing system for aquaculture.

For Post-harvest and Value addition, the goal is: "The quality of fish catch and fish products is optimized". The sub-goals / approaches and respective priority projects are as follows:

- Quality improvement of fish catches, with the projects i) Extension of improved on-board handling techniques for tuna handline fishery and ii) Strengthening capacity of ice making facilities.
- Valorization of fish products, with the project i) Extension of quality improvement methods for traditional processed fish, ii) Improvement of fish marketing system and iii) Development of katsuobushi processing technology and facility.
- Development of legal and institutional framework, with the project Development of the minimum national standards / regulations for fishery products.
- Strengthening of human resources capacity, with the project Establishment of a training system for fish quality assurance.

Subsequently, a roadmap has been established for each sub-sector to show the sequence of implementation of the various priority projects during the period of the Plan, i.e. 2016-2025.

INTRODUCTION

The Maldives consists of several coral atolls formed on the Chagos-Laccadive ridge, situated in the Indian Ocean, south west of the Indian subcontinent. The country is gifted with 1,190 coral islands surrounded with pristine and biologically rich marine environment. It is considered one of the largest coral reef ecosystems in the world. Its geographical location provides a unique opportunity to strengthen its role in regional and international trade.

According to the Maldives Census of 2014, the total population of the country is 407,660[1]. The population growth rate peaked at 3.43 percent[1] between 1985 and 1990 and has been declining since the mid-1990s to just below 2 percent[1] currently, even though the population continues to increase.

Despite a dispersed population, the Maldives has achieved notable development, with a sustained average growth rate of 6 percent[2] for the past two decades. Poverty rates have fallen sharply and human development indicators have improved greatly: Maldives has achieved five out of the eight Millennium Development Goals (MDGs) ahead of the 2015 deadline, making it South Asia's only "MDG+" country. Progress has been substantial in eradicating extreme poverty and hunger (MDG1), achieving universal primary education (MDG2), reducing child mortality (MDG4), improving maternal health (MDG5), and combating HIV/AIDS, malaria and other diseases (MDG6)[3]. From one of the world's least developed countries in the 1980s, Maldives is now a middle-income country with a per capita Gross Domestic Product (GDP) of US$ 7,221 in 2015[4].

About 90% of the Government's revenue comes from tourism and trade tariffs. From 2010 to 2014 economic growth averaged at about 6.0 percent[5]; however in 2015, it slowed to 2.8 percent[5], mainly due to the lower growth of the tourism sector.

Tourism and fisheries are the main sectors of the economy and the main sources of foreign exchange earnings; they contribute directly to about 40 percent[6] of the country's GDP, and indirectly for a much larger proportion of it.

These two sectors account for almost half of the national employment. The total labour force of the country is estimated at around 63 percent[7] of the working age population, i.e. about one in three working age Maldivians is currently outside the active labour force. Maldives has a high level of expatriate workforce; estimates indicate that in 2012 there were 111,579[8] regular foreign migrant workers in the country.

Like most Small Island Developing States (SIDS), Maldives faces a number of issues with regard to development. Due to both small population and limited landmass, it is a challenge for the private and the public sectors to establish commercial facilities. The large number of populated islands and their geographic dispersion make delivery of

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[1] National Bureau of Statistics (2015); Maldives - Population and Housing Census 2014
[2] http://www.indexmundi.com/maldives/gdp_real_growth_rate.html
[3] http://www.mv.undp.org/content/dam/maldives/docs/publicationsgeneral/MDG%20Mv%202010.pdf
[4] http://www.tradingeconomics.com/maldives/gdp-per-capita
[5] http://statisticsmaldives.gov.mv/nbs/wp-content/uploads/2015/09/GDP-Revision-ct2016.pdf
[6] http://www.mma.gov.mv/stat.php (2016): Overview of the Maldivian Economy
[7] http://statisticsmaldives.gov.mv/nbs/wp-content/uploads/2016/02/StatisticalReleaseIV-Employment.pdf
[8] Saeed S. (2015); Maldives Migrant Worker System Assessment Report 2015

services (health, education and infrastructure) very difficult and costly on a per capita basis.

The vast Exclusive Economic Zone (EEZ) of the Maldives (923,000 square kilometers[9]) has rich fishing grounds. Maldivians have coexisted with the marine ecosystems for centuries and are renowned for their sustainable and environmental friendly methods of fishing. The Maldivian fisheries sector has been the backbone of the country's economy, providing livelihood for the majority of the Maldivians and ensuring the main source of foreign exchange. It has achieved a high level of growth and development performance during the past three decades.

However, the contribution of the fisheries sector to the economy and its performances have declined over the past decade due to lower fish catches and drop of the prices of skipjack tuna on the international market. Nevertheless the fisheries sector is still an important sector in terms of employment, especially in the outer atolls, and it will continue to play a pivotal role in the Maldivian economy and social structure of the country.

Over the years, the Government of Maldives (GoM) has been playing a major role in the development and management of the fisheries sector in the country. It has made large investments in the processing industry and simultaneously, implemented major programs towards management and development of fisheries, encompassing development of fishing vessels, encouraging new fishing methods, installing fisheries-related infrastructure e.g. FADs, strengthening marine research, improving fish processing, promoting extension and improving the socio-economic situation of the fishing community; it has taken a series of measures to ensure sustainable management and exploitation of the fisheries resources.

Developing the fisheries sector is a priority for the Government. The Government's vision was laid out in the document "Open for Investment – Maldives Economic Vision 2013 – 2018; Building a Sustainable and Vibrant Economy"[10]. Based on this vision and the key manifesto pledges of the current Government, MoFA formulated a Strategic Action Plan (SAP) 2014 - 2018 for the sector. This Plan includes 5 policies which cover many of the essential elements and policy areas for fisheries management and development in the current context of the sector.

To integrate these various elements and provide proper guidance to the fisheries sector, a comprehensive Development Plan was needed. To that effect, GoM requested technical assistance (TA) from the Japan International Cooperation Agency (JICA) for the design of such a Plan, named the "Sustainable Fisheries Development Plan of the Important Sub-sectors in the Maldives" (SFDPIS). The TA project as such was called "Project for Formulation of Master Plan for Sustainable Fisheries in Republic of Maldives" or "MASPLAN".

The SFDPIS will guide all stakeholders in the fisheries sector; it describes the overarching strategic context of this sector, its challenges and opportunities, and includes priority projects for its sustainable development and management.

A sub-sector approach was adopted to formulate the SFDPIS; 4 sub-sectors, i.e. oceanic fisheries, reef fisheries, aquaculture and post-harvest and value addition, referred to as "the Important Sub-sectors", were defined on the basis of the main activities of the fisheries sector. The Plan therefore focuses on these 4 sub-sectors.

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[9] https://en.wikipedia.org/wiki/Fishing_industry_in_the_Maldives

[10] http://presidencymaldives.gov.mv/Documents/maldives_open_for_investment.pdf

Under the auspices of MASPLAN, a number of steps have been taken to ensure stakeholder involvement throughout the formulation process: i) one Sub-Sector Working Group (SSWG), composed of representatives of the fisheries sector (industry, management and research) and of other sectors (Environment, Tourism, Defense etc.) was set up for each of the sub-sectors and met regularly, as core leaders of the process; ii) , the socio-economic situational analysis of the fisheries sector was carried out with local communities in 7 selected atolls; iii) two Stakeholder Consultations were carried out in Malé with a large number of participants; and iv) a series of 6 pilot projects were implemented with specific stakeholders (fishing industry, resorts and fish traders, aquaculture industry) during MASPLAN to pre-assess the feasibility of projects to be developed within the SFDPIS.

The Plan includes priority projects and respective roadmaps for the sustainable development and management of these 4 sub-sectors. Some of these projects were designed on the basis of the outcomes of the 6 pilot projects implemented during the formulation process of the Plan.

CHAPTER 1 – OVERVIEW OF THE FISHERIES SECTOR IN THE MALDIVES

1.1 General Outline of the Sector

Fisheries plays an important role in the Maldivian economy in terms of employment, income, export earnings and revenue generation, but the sector has experienced a number of structural shifts in the past years. Thus its contribution to the GDP declined from around 22% in 1978 to about 1.5% in 2014 (Figure 1), as the output from other sectors such as tourism and services expanded. In spite of this dramatic decrease, the fisheries sector is still important in terms of employment, as it currently employs about 10 percent[11] of the labour force.

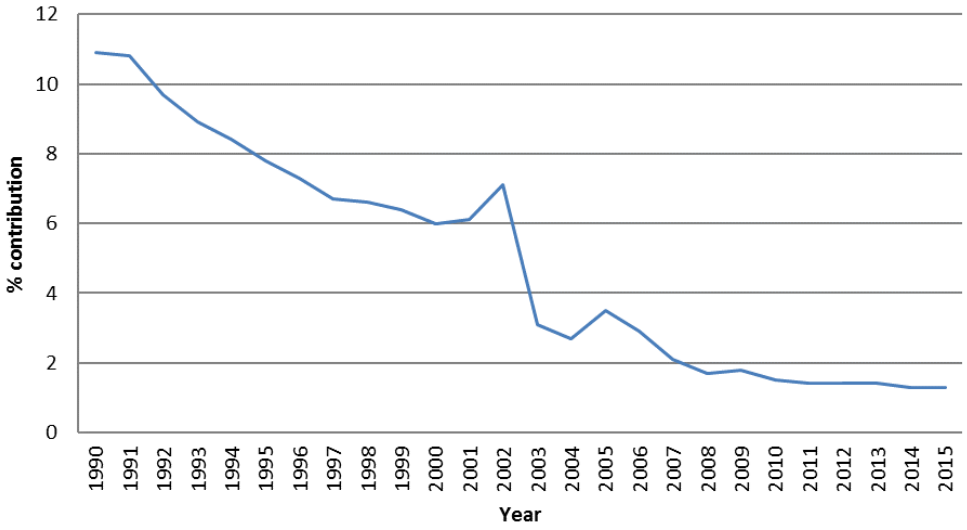


Figure 1 - Contribution of the fisheries sector to the GDG (%)

Sources: Basic fisheries statistics, MoFA;
hhtp://www.planning.gov.mv/publications/25yearsstats/25_yrs_stats/15_NationalAccount/15.1.htm

The performances of the fisheries sector as a whole have declined since 2006 due in particular to the decrease in fish catch and the fall in international tuna prices. In addition, the decline has been partly attributed to the rising operational costs, volatility of fuel prices and a general reduction of the active labour force working in the fishing industry.

[11] National Bureau of Statistics (2015); Maldives - Population and Housing Census 2014

1.1.1 Harvesting

Close to 90% of the total marine harvest in the Maldives comprise of tuna and tuna-related species; the species caught in the tuna fishery, in order of importance, are skipjack tuna (*Katsuwonus pelamis*), yellowfin tuna (*Thunnus albacares*), bigeye tuna (*Thunnus obesus*), kawakawa (*Euthynnus affinis*) and frigate tuna (*Auxis thazard*).

Over the past two decades the total annual fish catch increased steadily and peaked in 2005-2006 at around 180,000 tons, then decreased till 2012 (Figure 2). Since then a slow increase in the total catch has been recorded and in 2015 the total fish catch is estimated to be 120,000 tons. One of the fastest expanding segments of the Maldivian fisheries sector is the yellowfin tuna handline fishery, which started in the late 1990's – beginning of the 2000's and can be considered as a game changer in this sector: one of the reasons for the decrease in the annual catch of skipjack tuna could be due to the flexibility of pole-and-line vessels, switching the gear and moving into the yellowfin tuna fishery. Quite importantly, the Maldivian pole-and-line skipjack tuna fishery is "Marine Stewardship Council (MSC) certified" since 2012, and the yellowfin tuna fishery is in the process of certification.

Reef fisheries of the Maldives have grown substantially over the past two decades, linked to the expansion of tourism and new opportunities in international market, the growth in recreational fishing and an increasing demand for reef fish for local consumption. Major target species include several species of snappers, jacks, breams and groupers. Lobster and sea cucumber are also important species exploited in the country, although their catches have declined recently. The marine aquarium fishery began in the late 1980s and has gradually increased before stabilizing in 2012.

The annual reef fish harvest is estimated between 10,400 and 29,145 tons[12]. Like other coral reef ecological systems of the world, coral reefs of Maldives are rich in diversity but poor in abundance. Experience in the reef fish exploitation shows that once an uncontrolled fishery for a targeted species develops, over-exploitation occurs within a relatively short period of time; there are concerns that this may be the case for certain species.

The export of reef fish corresponds mainly to grouper (essentially live) and marine aquarium fish.

[12] Sattar S.A., Wood E., Islam F. and Najeeb A., (2014). Current status of the reef fisheries of Maldives and recommendations for management. Darwin Reef Fish Project (Marine Research Centre/Marine Conservation Society (UK)).

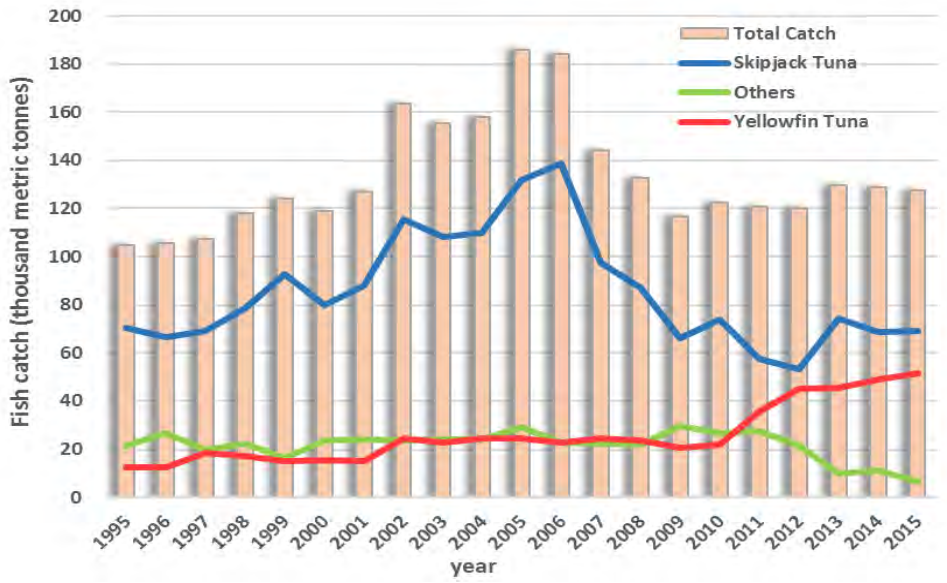


Figure 2 – Evolution of the fish catches in the Maldives – 1995-2015

Source: *Basic fisheries statistics, MoFA*

Aquaculture is still in its infancy in Maldives, even though development of this sub-sector has been a priority area of the Government for a number of years. To date, very few private entrepreneurs have ventured into aquaculture in the country; in order to introduce commercial scale aquaculture and encourage the private sector to invest in aquaculture, the Government is currently undertaking a number of activities and projects.

The number of active fishers operating tuna fishing, which had been steady at just over 20,000 during most of the 1990s, decreased to about 8,000 in 2015 (Figure 3). One of the main reasons for this decline is the reduction in the number of smaller fishing boats and a shift by some fishers to fewer but larger mechanized vessels, increasing employment opportunities in other sectors such as tourism and construction, and an apparent aversion by some young, educated men to work in the fisheries sector. In addition, the decrease may be linked to the improvement of the data collection system, requiring all crew of the tuna fishing vessels to be registered under each license, whereas previous data was based on mere estimates.

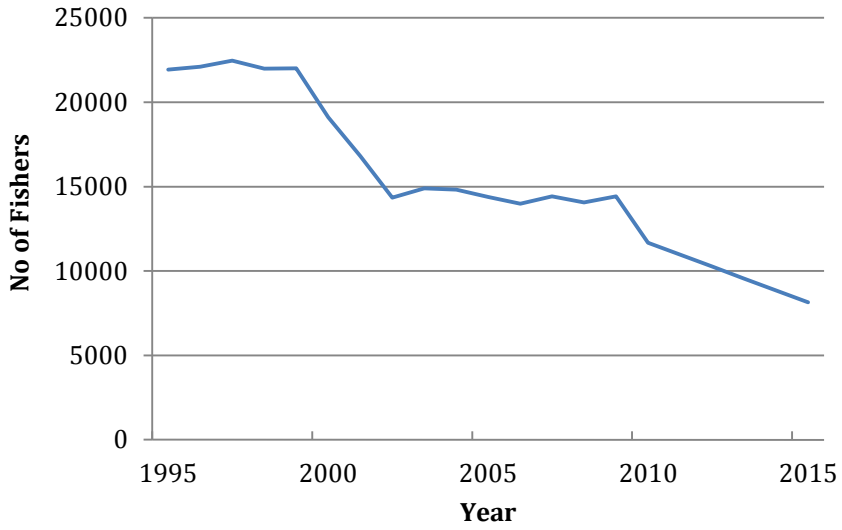


Figure 3 - Evolution of the number of active fishers engaged in pole-and-line and handline tuna fishery - 1995-2015

Source: Basic fisheries statistics, MoFA

One of the main factors that contributed to the expansion of the fisheries in Maldives is the introduction of mechanized fishing vessels from mid-1970s. Prior to the introduction of this type of vessel, the Maldivian fishing fleet consisted of sailing vessels, unable to go to the open sea in search of tuna schools. Along with the mechanization program, the Government implemented a very successful program to modify the design of the traditional fishing vessels that allowed the vessels to conduct fishing operations more efficiently. Under this program a large number of vessels were built and handed over to the fishing community on a hire-purchase basis.

Once the mechanization program was introduced, there was a sharp increase in the number of mechanized fishing vessels operating in the fishery. This trend continued till the mid-1990s, when this number started to decline.

However, this decline may not give an accurate assessment of the fleet as from the early 2000s the skipjack tuna fleet has been changing rapidly, from the traditional wooden vessels of approximately 15 meters, to larger Fiber Reinforced Plastic (FRP) vessels of 30 meters or more, often fitted with means of preserving fish on ice or with refrigerated sea water, more powerful engines and modern fish locating equipment. These larger vessels have good facilities for crew accommodation and are able to carry out multi-day fishing trips. The mechanized boats presently represent over 90 percent of all local fishing vessels.

1.1.2 Processing and Export

Fish and fisheries products represent over 95% of the total export value of the Maldives. In the early 2000s there was a marked increase in the annual value of export of fisheries products; this trend continued till 2007, when it dropped sharply. Traditionally the bulk of the fisheries export consists in skipjack tuna products; however, in recent years there has been a shift in processing and export toward higher value yellowfin tuna and its export value surpassed that of skipjack tuna. Currently the Maldivian fish processing and export sector is worth around US$ 160 million annually. The industry is dominated by skipjack and yellowfin tuna processing and export companies. In 2014 export of

yellowfin tuna and skipjack tuna contributed respectively to 53.3% and 37.8%, i.e. a combined 91% of the total export value of fisheries products.

The bulk of the skipjack tuna catch is exported in frozen form to Thailand as raw material for its canning industry. A substantial portion of skipjack tuna landings is processed into traditional smoked fish, which is mainly exported to Sri Lanka. The local price of skipjack tuna is considered still significantly lower than the world market (Figure 4)

Over the past three decades, large investments have been made to develop the skipjack tuna processing sector; there are currently 6 large scale tuna freezing plants established throughout the country, with a total daily capacity of about 800 t (including collector vessels and a barge), as well as two canning factories, with a total daily capacity of 130 t of raw material, that mainly produce skipjack tuna cans.

Both these canneries were approved by the EU. They also enjoy ISO 9002 and are in compliance to British Retailers Consortium Standard. The facilities were also approved by the European Food Safety and Inspection System (EFSIS) and the Campden (U.K.) independent laboratory.

In recent years the large yellowfin tuna fishery has become an important component of the Maldivian fisheries. It is mainly export-oriented and in terms of value has become more important than the skipjack tuna fishery. Yellowfin tuna processing and export activities are mainly carried out by the private sector and currently there are 8 yellowfin tuna processing factories operating in the Maldives, with a total daily capacity of about 135 t of raw material. All are approved by the European Union. The majority of the large yellowfin tuna is exported chilled or frozen to markets in Far East Asia, Europe and USA. For export purposes yellowfin tuna is classed into three grades, A to C, depending on its freshness and quality; while grade "A" fetches very high prices, grade "C" does not obtain attractive prices and is mostly sold on the local market.

Figure 4 - Comparison of world market prices and local purchasing prices of skipjack tuna - 2005-2015

Source: Basic fisheries statistics, MoFA

1.1.3 Institutional Framework

The overall administration of the fisheries sector lies with the Ministry of Fisheries and Agriculture (MoFA), in close coordination with relevant authorities such as Maldives National Defense Force (Coast Guard), Maldives Customs Service, Maldives Police Service, Ministry of Environment and Energy, Ministry of Tourism, etc. The mandate of MoFA is to develop the fisheries sector and provide the legal framework required for the development and management of fisheries and other marine resources. MoFA develops and implements regulations concerning the sustainable exploitation of resources from the marine environment.

Under the current organizational chart of MoFA, the Fisheries Division is its largest division, with 37 staff. In addition, the Marine Research Centre (MRC) currently has 16 staff and conducts important research in several different aspects of fisheries including oceanic fisheries, reef fisheries, aquaculture, coral reef and protection of endangered species.

The tuna stocks exploited in the Maldives occur throughout the Indian Ocean and are exploited both in the high seas (outside of the 200 nautical miles limit of the EEZ) and within the country's EEZ. The sustainable development of the Maldivian tuna industry therefore requires the implementation of management measures both at national and regional level.

At the national level, Maldives has kept records of tuna landings in the country since the early 1970s, through a national fisheries data collection based on an enumeration system. To strengthen this data collection, MoFA initiated in 2010 a program to replace this system by a modern logbook-based one. In addition, an online web-enabled database was launched at the end of 2015, which allows easy compilation and processing of catch and effort data; it is also used by the exporters to record tuna purchases; this web-enabled database is still in the developmental stage and when fully functional, it is expected to maintain records of active fishing vessels and fishing licenses.

At the international level, Maldives is a party of the United Nations Convention on Law of the Sea (UNCLOS) which requires cooperation of coastal states and other fishing states to ensure the conservation and promotion of optimum utilization of highly migratory species within and beyond the coastal EEZs. In addition, the Maldives became a full member of the Indian Ocean Tuna Commission (IOTC) in July 2011 and since then has played a very active role in promoting sustainable exploitation of resources in the region.

1.1.4 International cooperation

A series of NGOs have been involved in the past years or are still involved in the sector. A project supported by FAO has recently been covering legal and compliance aspects of fisheries. JICA is supporting the formulation of the present SFDPIS.

In addition, two major partners are currently involved in the fisheries sector development, i.e. the International Fund for Agricultural Development (IFAD) and the World Bank Group (WBG). Two projects are currently under implementation.

The "Mariculture Enterprise Development Project" (MEDeP) is a 5- year project initiated in 2012, co-funded by a US$ 2.49 million IFAD grant[13]. Its main objectives are to (i) enhance the capacity of MoFA to regulate and manage the mariculture industry, (ii) strengthen the capacity of the private sector including companies, small and medium enterprises and individual entrepreneurs to invest and participate in the mariculture

[13]IFAD, 2012. Mariculture Enterprise Development Project (MEDeP), Design Completion Report, Asia and the Pacific Division, Programme Management Department, Report No.2859-MV, July 2012.

value chain and (iii) increase the capacity of poor households, targeting particularly women and youth, to achieve productive gains from the mariculture sector.

The "Sustainable Fisheries Resources Development Project" (Fourth South West Indian Ocean Fisheries Governance and Shared Growth Project) is co-financed by a US$ 18 million grant from the International Development Association of the WBG, over the period 2017-2022. The aims of the Project are as follows: (i) in the larger South-West Indian Ocean Region, to improve the management of selected priority fisheries at regional, national and community levels and (ii) at the national level, to enhance the Government's capacity to manage and govern the fisheries sector, including formulating appropriate adaptive sector policies; to ensure sustainability of marine fisheries; and to develop mariculture as an important source of inclusive growth of economy, income and jobs.

These two projects will be instrumental in the implementation of the present SFDPIS.

1.2 Sub-Sector Analysis

This section presents the summary outputs of the participatory sub-sector analysis which was carried out during the period 2015-2017, through various stakeholder consultations and with the assistance of the four Sub-Sector Working Groups (SSWGs) composed of representatives of the respective stakeholders.

1.2.1 Oceanic Fisheries

A summary of the SWOT analysis for the Oceanic Fisheries Sub-Sector (skipjack tuna and yellowfin tuna fisheries) is presented hereafter.

a) Strengths

The Strengths of the skipjack and yellowfin tuna fisheries are as follows:

- Maldives plays a significant role in promoting participation of the coastal states in decision making processes. Its participation is crucial in sustainable utilization of the resources in the Indian Ocean as Maldives targets around 95% of its catch on these resources.
- The tuna fisheries continue to play a vital role in the local economy of a large number of islands, as they provide employment opportunities and income for thousands of households. The socio-economic well-being of these communities is inherently tied to these fisheries and the communities thrive in good fishing periods.
- There is a committed and experienced workforce in both the skipjack and yellowfin tuna segments, with fishing and seamanship skills developed over the years; vessels are also capable of switching from one target species to the other depending on the season.
- The skipjack tuna fishery is structured in a way that fishers are able to spend a reasonable time onshore with the family, which encourages youth to enter the fishery.
- At present, the Maldivian skipjack and yellowfin tuna fleet mostly comprises of large FRP vessels which are capable of travelling great distances in search of tuna schools and are equipped for fish chilling onboard. These vessels offer better accommodation to crew and use better technology in their fishing operations.
- The Fish Aggregating Devices (FADs) deployed by MoFA have been instrumental in providing a reasonably stable skipjack tuna catch for the national fishing fleet (i.e. the small vessels operating near the atolls).

- The tuna fishery provides raw material to small-scale fish processors, which is very important on islands where opportunities for income generating activities are limited.

b) Weaknesses

The Weaknesses of the skipjack and yellowfin tuna fisheries include the following:

- Evident decline in skipjack tuna landings, due to the low rate of encounters with free swimming schools, reportedly results from large numbers of drifting FADs (d-FADs) deployed by purse seiners within the region. This results in a need for fishing vessels to travel greater distances in search of such schools, considerably reducing the catch per unit effort, and in the operation being more costly.
- The availability of bait has become more limited in recent years, resulting in greater distances travelled and more time spent in search of bait. It has become increasingly challenging to get adequate bait for the larger vessels.
- While large vessels currently used in the Maldivian tuna fleet offer many advantages, their operational costs are high and during low fishing periods, they are forced to stay in harbor, which hampers their profitability. Moreover, this issue is exacerbated by fluctuating fuel prices.
- Although MoFA installed a network of about 50 FADs throughout the country, their maintenance continues to be a challenge to MoFA.
- Post-harvest loss of economic value of skipjack tuna catch arising from poor quality continues to be an issue for the skipjack tuna fishery. Even though most large vessels use ice to maintain the freshness of the catch, sometimes ice is not available in required quantities and under high temperatures, freshness and quality of fish rapidly decrease on board and after landing.
- The policy framework for the tuna fishery shows limitations; important aspects such as easy access to finance and appropriate pension scheme for fishers are not fully developed. Recently the Government introduced an insurance scheme for fishers, which needs further improvement.
- Although infrastructure and services for the Maldivian fisheries sector has increased significantly in the past two decades, there are still some deficiencies: access to ice, water, engine spare parts and fishing gear continues to be a challenge in some atolls.

c) Opportunities

The Opportunities of the skipjack and yellowfin tuna fisheries include the following:

- Since tuna are migratory species, their management requires cooperation and collaboration at regional and international levels. Knowledge and research on tuna management has improved globally over the recent decades.
- There is a growing demand on the international market for skipjack tuna products derived from fish harvested through environmentally friendly means which are paid “premium” prices; the Maldivian skipjack fishery is already MSC-certified and Maldives has applied for yellowfin tuna to be MSC-certified as well. The country should expand more on this niche market and explore opportunities to produce new products from the skipjack and yellowfin tuna fisheries.
- Many private operators are expressing interest in investing in fisheries-related businesses such as provision of fuel, ice, engine spare parts etc.

- Banks such as the Bank of Maldives and other lending institutions are exploring ways to expand financing to sectors other than tourism, which may possibly offer opportunities for the tuna industry.
- There is a clear commitment from the Government to develop and manage the fisheries sector sustainably.
- There is also a willingness by bilateral and international organizations, e.g. JICA, IFAD and the World Bank, to assist the Maldivian fisheries sector.

d) Threats

The Threats that the skipjack and yellowfin tuna fisheries face include the following:

- Tuna purse seine fishing in the Indian Ocean is increasing and simultaneously, the increase in the number of d-FADs may be having a strong impact on the stocks of tuna in the region, with changes in their behavior patterns and subsequent difficulty in stock assessment. In addition, the issue of Illegal, Unreported and Unregulated (IUU) fishing by foreign vessels is likely to be increasing in the Maldivian EEZ itself. These activities may put both skipjack and yellowfin tuna fisheries at risk.
- In the case of the yellowfin tuna fishery, IOTC has determined that the stock in the Indian Ocean is overfished and subject to overfishing.
- There is concern that the bait resources in the country may become unsustainable, due to heavy exploitation to cater for the increasing demand from the large vessels operating in the tuna fishery.
- The Maldivian skipjack tuna fishery is currently "MSC certified", a strong indication that the resource that is targeted by the fishery is sustainably managed. In the case of the Maldivian tuna fishery, this certification also implies that the bait fishery resources are managed in a sustainable way; if coherent and effective measures to manage the bait resources are not implemented immediately, the Maldivian tuna fishery might lose the MSC certification.
- Unprecedented economic growth has been witnessed in the Maldives in the last three decades, which led to social changes and created new job opportunities. People have become better educated, more exposed to the outer world through access to media and travelling, and the expectations of the younger generation have increased: this generation is more eager to be economically active in white-collar jobs, and working in the fishing industry is not seen as attractive to many young Maldivians; hence, while the fisheries sector is growing, finding young Maldivians willing to work in the sector is a challenge.
- Possible conflicts between the fisheries and the tourism sectors may arise in the future: resorts protect nearby local reefs and inshore areas from commercial bait fishing; currently, the tourism sector is undergoing an expansion phase and a number of resorts are being developed in outer atolls, resulting in more limitation in bait fishing grounds;.
- Global warming and other environmental issues may become critical for the oceanic fisheries in the next decades.

1.2.2 Reef Fisheries

A summary of the SWOT analysis for the reef fisheries sub-sector is presented hereafter.

a) Strengths

The Strengths of the reef fisheries are as follows:

- The expansion of tourism has created good market opportunities for reef fishers and fish middlemen.
- The economic return from reef fishing, particularly from the grouper fishery, is excellent, as the prices of reef fish are high.
- The reef fisheries are currently structured in a way that fishers are able to spend reasonable time onshore and attend their family, which encourages youth to enter this sub-sector.
- Most reef fishers are experienced, with fishing skills developed over the years; with more and more youth entering into this sub-sector, the transfer of skills and technology from experienced fishers to the youth is high.
- As most reef fishing activities are carried out with small-scale vessels, it is relatively easy to enter into the fishery, thanks to relatively low investment and operating costs. This fact is very important on islands where opportunities for income generating activities are limited.

b) Weaknesses

The Weaknesses of the reef fisheries includes the following:

- The data collection mechanism as a basis for research and monitoring is insufficient.
- Development of specific reef fisheries has been driven by a high demand on export markets (e.g. for live grouper, sea cucumber and aquarium fish); often, due consideration to their management is hardly given after concerns regarding their status have appeared. For the grouper fishery, there is high pressure on certain high value species and under-sized fish is kept in cages to be grown, which is detrimental to the stocks.
- MoFA has limited capacity (in terms of equipment, funding and skilled human resources) to monitor reef fish catches (e.g. size limits for groupers, discards and logbook filling). There is also insufficient communication between fishers and MoFA officials on important aspects of administration such as grouper cage registration.
- The vessels used in the reef fisheries are relatively small in comparison with those used in the tuna fishing industry; their accommodation is not adequate, which hinders youth from engaging in the sub-sector.
- For the grouper fishery, safety of divers is a serious concern.
- The current infrastructure of the Maldives fisheries sector is not geared towards catering the reef fishing industry. As a result, access to ice, water, engine spare parts and fishing gear continues to be a challenge for reef fishers.

c) Opportunities

The Opportunities for the reef fisheries include the following:

- The market for reef fish is increasing and there is growing international demand for fresh reef fish products, caught through environmentally friendly means.
- A number of resorts are due to open in atolls where there are currently none, which will create market opportunities for the reef fishers in these atolls.
- Many private business entities are expressing interest in investing into fisheries-related business such as provision of fuel, ice, engine spare parts etc.

- There is a clear commitment from the Government to develop and manage the fisheries sector sustainably.
- There is also willingness by bilateral and international organizations to assist the Government in its efforts.

d) Threats

The Threats that the reef fisheries face include the following:

- A continued increase in reef fish harvesting of currently targeted species could possibly cause overexploitation.
- Even though there is no evidence of over-exploitation of bait, the bait resources of the country may become unsustainable in the future, due to heavy exploitation to cater for the increasing demand from the large vessels operating in the tuna fishery.
- The growth of other economic sectors and the opening of resorts in outer atolls will create new economic opportunities for youth, and youth currently employed in the reef fisheries might move away from it.
- Loss of reef fish habitats linked to global warming and other environmental issues may become critical for the reef fisheries in the coming decades;tThe degradation or destruction of habitats as well as the increase in development projects represent major threats. Physical infrastructures are being undertaken on many islands and near their shore to support the local population and develop tourist resorts; these developments have adverse impact on the adjacent reefs and reef environment. In addition to the coastal infrastructure development, dredging activities and dumping of waste in the coastal and marine environment is a serious issue on many islands.
- A number of tourist resorts are being developed and the respective areas are closed for fishers; adding to it, large areas within atolls are being declared as Marine Protected Areas (MPAs). These measures adversely affect reef fishers due to the loss of fishing grounds and conflicts with the tourism sector may possibly arise in the future.

1.2.3 Aquaculture

A summary of the SWOT analysis for the aquaculture sub-sector is presented hereafter.

a) Strengths

The Strengths of the Maldivian aquaculture includes the following:

- Maldives is blessed with various marine environments whose characteristics are favourable for different types of aquatic animals.
- Over the past half century appropriate aquaculture technologies have been developed worldwide, that vary from simple facilities such as small ponds to high technology with intensive closed systems. Most of the technology possibly used in aquaculture in the Maldives is relatively simple and only requires small adjustments to improve the growth and survival rates of the target species. Maldives can import appropriate technologies and adapt them to the local environment.
- High quality broodstock of high-value marine species with aquaculture potential that have not been genetically contaminated / deteriorated are available in the Maldives.

- There are established export markets for high-value marine finfish and invertebrates, which could be tapped into by the emerging Maldivian aquaculture sector.

b) Weaknesses

The Weaknesses of the Maldivian aquaculture industry include the following:

- Although MRC is carrying out important research work in the field of aquaculture, this work is insufficient to address the needs of the industry growth. Aquaculture development requires scientific research to enable better understanding on species biology, nutrition, growth, spawning, recruitment, disease etc. as well as on the economic feasibility of the enterprise. Research should be focused on the species being cultured and can be coordinated with similar research institutions in other parts of the world.
- Unavailability of technically competent local human resources is a constraint for the aquaculture industry, and Maldives needs to quickly develop the required technical capability in the initial development stage of the industry.
- The current legal structure of the fisheries sector is weak on legislature relating to the management and development of aquaculture. The sustainable development of the sub-sector requires that adequate legislative and regulatory framework be developed to support it.
- Access to finance for aquaculture projects is a constraint at the early stages of development of the industry; initial investments are usually too high for the average investor; risk of capital investment in an industry yet unproven in the country might deter banks from lending at the initial stage.

c) Opportunities

The Opportunities for the Maldivian aquaculture industry include the following:

- The aquaculture industry has grown worldwide at an unprecedented rate over the past decades. This growth has helped to produce more food fish and made fish and seafood more accessible to consumers around the world. The international market for aquaculture products is expected to continue to expand and there are clear opportunities for the Maldivian aquaculture industry to establish itself and grow.
- A significant quantity of raw material required for fish meal production is available as by-product from the local fish processing industry. As feeding costs for marine aquaculture contributes to a large bulk of the total production costs, the production of a low-cost feed using locally-sourced fish meal provides opportunities to reduce these costs.
- Many private entities are expressing interest in investing in fisheries-related businesses such as aquaculture.
- There is a clear commitment from the Government to sustainably develop and manage the aquaculture industry. MoFA's Strategic Action Plan defines the development of aquaculture as one of the main focus areas for the fisheries sector.
- There is willingness by bilateral and international organizations to assist the Maldivian fisheries sector. Several donor-funded projects on aquaculture development have been and continue to be implemented in the Maldives.

d) Threats

The Threats that the Maldivian aquaculture industry faces include the following:

- Aquaculture is a very well developed industry worldwide, especially in South-East Asia. The operational costs in most countries are relatively low compared to the Maldives. Hence, outside competitors might be in a position to offer better prices for the same product, unless marketing for Maldivian products is done very carefully.
- The market for some of the aquaculture species like grouper is highly volatile, price variations are high and it is difficult to forecast the demand.
- The Maldives has an extremely delicate and fragile marine environment. Any commercial activities that might have detrimental effects on it have to be carefully regulated and monitored. There are threats to the environment if aquaculture industry is developed without sound regulations to safeguard the environment.
- Aquaculture in other countries has been partly based on farming of exogenous species, and the same may be applicable in the Maldives. However, invasive non-native species are known to be one of the main causes of altered ecosystems and biodiversity loss, and proper research and management are needed to avoid this critical issue.

1.2.4 Post-harvest and Value Addition

In order to provide a clear picture of the sub-sector, small-scale traditional fish processors (i.e. those processing less than 3 tons of raw material per day) and large-scale fish processors were analyzed separately, as their respective scale of operation, infrastructure and other business factors as well as the issues they face are different.

A) Small-scale operators

A summary of the SWOT analysis for the small-scale fish processors is presented hereafter.

a) Strengths

The Strengths of the small-scale traditional fish processors include the following:

- Small-scale fish processing plays an important role in the local economy of some island communities by providing employment opportunities and income, especially for women, which is very important on some islands where opportunities for income generating activities are limited.
- Small-scale fish processing implies relatively low technology, initial investments and start-up costs.
- There is easy access to market and established distribution channels for the products (mainly boiled, smoked and sun-dried tuna and salted, sun-dried reef fish).

b) Weaknesses

The Weaknesses of the small-scale traditional fish processors include the following:

- Small-scale processors require large open areas with direct sunlight for drying fish; in some small islands, obtaining large areas of land is a challenge.
- Small-scale processors lack proper infrastructures such as fish handling, cooking and drying facilities and storage areas; as a result, the quality of the products is

affected and processors are forced to sell the fish at low prices when the market is saturated.

- During the lean fishing periods the small-scale operators face a shortage of raw material, as they have to compete with the large-scale fish processors who are often in a position to pay higher prices for it.
- Small-scale processors are scattered throughout the country and do not operate in a collective manner; as a result, they are not in a position to jointly negotiate important aspects of business such as purchasing prices of raw material and selling prices of products.
- Currently there are no established quality standards or a proper mechanism to implement such standards for the products of the small-scale processors; consequently, there are no incentives for processors to maintain quality.
- Even though initial investments are relatively low for small-scale processing, processors do require a substantial working capital to purchase fish if they are to operate on a reasonable scale, and access to finance for small and medium scale processors is a major challenge. There is no real development service offered by the National Bank and other commercial banks.
- Most small-scale fish processors employ expatriates who do not have knowledge or skills on the critical steps of traditional fish processing techniques, what affects the safety and quality of fishery products.
- Involvement of expatriates in traditional fish processing activities could be the main reason for the low engagement of local men and women in these activities in good fishing islands. Conversely, low pay to local people is a major cause of reluctance to work in fish processing in the islands.

c) Opportunities

The Opportunities for the small-scale traditional fish processors include the following:

- The market for smoked-dried tuna products is increasing in Sri Lanka, which is the main market for these products.
- The Government has recently announced different soft loan schemes for Small and Medium Enterprises (SMEs); these schemes do not require collaterals and the loan processing times are short.
- There are niche market opportunities for small-scale processors in markets as Japan, where demand is growing for products such as katsuobushi[14]; with a proper product diversification strategy, small-scale processors can target these niche markets.
- There is clear commitment from the Government to assist small-scale fish processors through extension and market assistance programs.

d) Threats

The Threats that the small-scale traditional fish processors face include the following:

- Large-scale fish processors are expanding their operations and new operators are entering into the industry, which represents a challenge for the traditional small-scale processors in terms of competition for supply of fresh fish and availability of labour.

[14] Katsuobushi is dried and smoked skipjack tuna, obtained through a specific processing procedure; it commands high prices on the Japanese market.

- Fresh fish supply to small-scale traditional processors is highly irregular, as fishers tend to sell their harvest to large-scale processors at higher prices during the lean fishing periods; small-scale processors are then unable to compete in terms of price and availability of fresh fish.
- The main overseas market for the small-scale fish processors is Sri Lanka; any change in the import duty regime or implementation of stringent quality assurance measures by the Sri Lankan Government would have a large impact on small-scale processors.
- Boiled, smoked and sundried fish, the main product of the small-scale fish processors, requires long hours of uninterrupted sunshine for the drying process, and recent changes on weather patterns have been causing concerns. In general terms, global warming and other environmental issues may become critical for these processors.

B) Large-scale operators

A summary of the SWOT analysis for the large-scale fish processors is presented hereafter.

a) Strengths

The Strengths of the large-scale fish processors include the following:

- Most large-scale fish processors have established modern processing facilities with all the required equipment and machinery. Most factories are planned in a way that allows future expansion and have excellent staff facilities including good accommodation.
- Consumers in markets currently catered to by Maldivian large-scale processors want to ensure that seafood they consume originates from sustainably managed fisheries; the Maldivian skipjack tuna fishery currently enjoys the MSC certification, which puts the Maldivian large-scale processors in a strong position in terms of access to markets.
- Some youth are interested to work in the factories, especially in the skilled and technical areas, thanks to proper accommodation, incentives and training opportunities offered by the large-scale processors.
- In order to address the issue of insufficient resources, knowledge and organization of the industry to carry out effective marketing, the Maldives Fisheries Promotion Board has recently been created. Whereas before, large-scale processors were undertaking marketing and attending trade events on an individual basis, the Board is quite instrumental to support the marketing activities of the processing industry.

b) Weaknesses

The Weaknesses of the large-scale fish processors include the following:

- The quality of the final products depends on the quality of the fresh fish, but there is no minimum national standard for fresh fish.
- In the Maldives the production costs of large-scale processors are considerably higher than elsewhere in the region: all production inputs, apart from the raw material, have to be imported; labour costs are high and processors have to invest in auxiliary infrastructures such as power, water, accommodation and staff facilities etc. Capital costs are also very high in Maldives and financing is unavailable.

- A number of large-scale fish processing facilities currently established in the country is underutilized, namely the two tuna canneries. This excess or underutilized capacity implies that these factories incur increased fixed costs, with adverse effects on their sustainability.
- There is a seasonal variation in fresh fish supplies; large-scale processors find it difficult to acquire enough raw material during the lean fishing periods.
- Large-scale processors face difficulties in finding enough local skilled workers to meet their requirements. This problem is likely to worsen in the coming years as new resorts are being built and attract young people, since working in fish processing factories is often considered by the younger generation as tedious and is not highly regarded.

c) Opportunities

The Opportunities for the large-scale fish processors include the following:

- Maldives has been fishing skipjack tuna sustainably for centuries; the fishery is now MSC-certified and the products have access to niche markets in the EU and the USA, which could be further promoted.
- There is a growing demand for fish products in the Middle East, a market characterized as primarily driven by price rather than quality, with low tariffs and relatively easy to access. This market can be attractive for Maldivian fisheries products, linked to the increasing purchasing power in the region. It can also be a good market for high-end premium products.
- Increasing purchasing power and the subsequent changes in consumption habits, particularly in the western countries, have resulted in an increase in demand for value-added ready-to-eat or ready-to-cook fish products. Recent developments in fish processing technologies are oriented towards diversification and quality assurance, and there are clear opportunities for the Maldivian large-scale fish processors to target this market and diversify their current product portfolio in order to gain competitive advantage and maximize returns.
- A large amount of skipjack tuna is exported frozen, mainly to canneries in Thailand; the two skipjack tuna canneries currently in operation in the Maldives are underutilized and efforts should be made to increase their production of cans and other products, instead of exporting frozen skipjack tuna.
- There is a clear commitment from the Government to develop and manage the fisheries sector sustainably, and also willingness by international organizations to assist this sector.

d) Threats

The Threats that the large-scale fish processors face include the following:

- The Maldives has lost 24% duty concessions to Europe, which is an important market for large-scale fish processors, where they are currently selling at very small profit margins. In addition to tariffs, the Maldivian fish processors' ability to gain market access to the EU and other developed countries is becoming increasingly difficult due to non-tariff measures such as certification requirements. Maldivian processors have limited capability to meet these requirements, and when they do so, their production costs are increased even further.

- Prices of fish and fishery products remain volatile on the international market. Usually the fish harvesting sector in the Maldives tends to be isolated from price changes in the international market, as the prices paid to the fishers are fixed, whereas the processors are impacted by the changes of the international market.
- The current regulatory regime governing the fish processing and export process in the Maldives is insufficient to cater to the successful and smooth operation of the large-scale fish processors. For example a number of foreign parties are currently operating in this industry using a Maldivian as a proxy; they do not invest in any infrastructure nor pay taxes. Hence they are able to purchase fish at higher prices than the Maldivian processors who have heavily invested and pay appropriate taxes.
- The Maldivian skipjack tuna fishery is currently "MSC certified", as the natural resources that are targeted are recognized as being sustainably managed. However, due to the issues related to sustainable management of the bait stocks, there is a chance of Maldives losing the MSC certification. This would imply that the processors would lose the niche markets they currently target and subsequently the purchasing prices from fishers would drastically decrease.

1.3 Summary of issues to be addressed by the Plan

The SWOT analysis, as presented above, has been refined through a problem / objective analysis for each sub-sector. As a result, the overall picture of the fisheries sector clearly shows that in spite of a number of weaknesses and threats, the sector enjoys considerable strengths and could benefit from existing opportunities.

The purpose of the SFDPIS is to build on these strengths and opportunities and simultaneously, address the weaknesses and mitigate the threats. This Plan will encompass a comprehensive series of components, i.e. fisheries resource management, technological development, training and awareness, legal and institutional framework, human resources and financial system.

The major core issues facing the various sub-sectors and their respective causes which have been identified are summarized hereafter.

1.3.1 Oceanic fisheries

- The core issue is: "The opportunities to benefit from the oceanic fisheries resources are not fully taken advantage of".
- Its major causes are as follows:
  - Deficiencies in the oceanic fisheries management system.
  - Limitations in the technological development of tuna fisheries.
  - Underutilization of existing fish resources.
  - Limitations in the public services to fishers.

1.3.2 Reef fisheries

- The core issue is: "The reef resources are not exploited in an ecologically and economically sound manner".
- Its major causes are as follows:
  - Deficiencies in the current reef fisheries management system.
  - Limitations in the technological development of reef fisheries.
  - Limitations in the public services to fishers.

1.3.3 Aquaculture

- The core issue is: “The aquaculture industry is still underdeveloped in the Maldives”.
- Its major causes are as follows:
  - Limitations in the technological development.
  - Insufficiency of the extension services.
  - Limitations in the management system.
  - Inexistence of an adequate financial system.

1.3.4 Post-harvest and Value addition

- The core issue is: “The quality of fish catch and fish products is not optimal”.
- Its major causes are as follows:
  - Deficiencies in the quality of fish catches.
  - Deficiencies in the value addition of fish products.
  - Limitations in the legal and institutional framework.
  - Limitations in human resources.

CHAPTER 2 - SETUP OF THE PLAN

2.1 Policy Framework of the Fisheries Sector

2.1.1 Government's Vision for the Sector

Fisheries are a priority development sector of the Government. The Government's vision was laid out in the document "Open for Investment – Maldives Economic Vision 2013 – 2018; Building a Sustainable & Vibrant Economy". For the fisheries sector, the vision is as follows:

- Strengthen the concept of eco-friendly / dolphin-friendly fishing in the Maldives.
- Strongly advocate the pole-and-line sustainable fishery.
- Diversify the fishing sector by creating an enabling environment to harvest in the EEZ.
- Invest in targeted aquaculture.
- Maldives to be recognized as one of the highest standard processor and exporter of value-added skipjack and yellowfin tuna to major European, American, Middle East and Far-East markets.

2.1.2 Strategic Action Plan and Fisheries Policy 2017

Based on the Government's vision for the fisheries sector and key manifesto pledges of the current government, MoFA has developed a Strategic Action Plan (SAP) - 2014-2018 for the sector, which stipulates the following 5 policies:

- Enable ways to support fisher's families financially during low fish catch periods.
- Develop fisheries infrastructure, improve quality of fish catch and increase exports.
- Increase youth involvement in the fisheries industry.
- Establish and develop the aquaculture industry.
- Maintain the Maldivian fishery as a world-recognized model for responsible and sustainable fishing.

MoFA is currently in the process of formulating a new comprehensive policy guideline for the fisheries sector ("Fisheries Policy 2017"). Its main objective is to outline a framework to manage and develop a sustainable fisheries sector, keeping in mind the national economic growth, food security and poverty alleviation. The policy guideline, still in a draft form, covers the following areas:

- Management of fisheries resources.
- Development and management of aquaculture.
- Diversification and value-addition of the fisheries sector.
- Promotion of the fisheries history, culture, and sustainable fishing methods such as the "pole-and-line to catch fish one by one".
- Diversification of fishing gear and targeted natural resources.
- Deployment and management of Fish Aggregating Devices.
- Promotion of foreign investment.
- Introduction of alien species for aquaculture.

- Enhancement of marine scientific research.
- Reinforcement of the regional cooperation.

2.1.3 Fisheries Act

The main legislative tool governing the fisheries development and management of the Maldivian fisheries sector is the Fisheries Act of the Maldives. It came into effect in 1987 and has limitations to address various challenges currently faced by the sector: there are no provisions in the Act to ensure sound governance, especially in terms of achieving long-term sustainable management of living marine resources, a precondition for maintaining the social and economic value of these resources. In addition the Act is inadequate to meet the national obligations arising from Maldives being party to various international conventions such as UNCLOS. These gaps are filled through various regulations enacted under the broad scope of the Fisheries Act.

Given the recent development trends in the fisheries sector of the Maldives and the importance of this sector to the national economy, it was imperative that solutions be found to deal with any shortcomings of the current Act. Therefore, the Maldivian Government initiated the revision of the Act, with the assistance of an FAO project[15]. As of beginning of 2017, a draft for the revision of the Act has been finalized ("Fisheries Bill") and has been sent to the Attorney General's Office for it to be tabled in the Parliament.

The objectives of this Act, as per the current draft, are as follows:

- To provide for the long-term conservation and sustainable use of the fisheries resources of the Maldives for the present and future generations of the Maldives.
- To provide a framework for a transparent management of the fisheries resources of the Maldives in accordance with principles of equity and good governance.
- To promote value addition to the fish and fisheries products of the Maldives with a view to ensuring the maximum economic and social benefits to the Maldives.
- To promote efficient and effective regulation of the aquaculture industry in order to contribute to the protection of the marine environment of the Maldives, support economic development and food security for the people of the Maldives.
- To provide an effective framework to prevent, deter and eliminate Illegal, Unreported and Unregulated fishing.
- To ensure a timely and effective implementation of international obligations regarding conservation and management of fisheries of the Maldives.

The present SFDPIS will be implemented in conformity with this new Fisheries Act.

2.2 Strategic Vision, Goals and Guiding Principles of the SFDPIS

The Sector Plan Drafting Committee (SPDC) of MASPLAN took into consideration the sub-sector analysis in developing the Strategic Vision, the Goals and the Guiding Principles of the SFDPIS, which is fully in conformity with the current SAP of MoFA.

2.2.1 Strategic Vision

The Strategic Vision of the Plan is defined as follows:

"The fishing industry is efficiently managed and sustainably developed for a better future for the Maldivians, where marine resources are exploited in a sustainable manner

[15] Assistance in support of the fisheries and aquaculture sector (FAO Project TCP/MDV/3501), component on review of fisheries and aquaculture legal framework.

while maximizing social and economic benefit of the sector, by way of foreign exchange earnings through expanded export commodities and returns from foreign investment, generating job opportunities and a stable domestic supply of safe animal protein."

2.2.2 Goals

a) Overall goal of the SFDPIS

The overall goal of the SFDPIS is to provide the Ministry in charge of the sector with the framework to fulfil its overall mandate, i.e. "to manage and develop all marine living resources in the maritime zones of the Maldives in a sustainable manner".

b) Goals of the sub-sectors

The goals of the SFDPIS were set forth for each sub-sector; they derive from the respective sub-sector analysis and correspond to the main objectives to be reached through the resolution of the core issues for each sub-sector.

The sub-goals for a sub-sector correspond to the resolution of the main causes of the core issue. Therefore, the goals and sub-goals of the sub-sectors are as follows:

- For Oceanic Fisheries, the goal is: "The opportunities to benefit from the oceanic fisheries resources are fully taken advantage of".

  The sub-goals are as follows:

  - The oceanic fisheries management system is adequate.
  - The technological development of tuna fisheries is optimized.
  - The exploitation of underutilized resources is developed.
  - Public services to fishers are adequate.

- For Reef Fisheries, the goal is: "The reef resources are exploited in an ecologically and economically sound manner".

  The sub-goals are as follows:

  - The reef fisheries management system is adequate.
  - The technological development of reef fisheries is optimized.
  - Public services to fishers are adequate.

- For Aquaculture, the goal is: "The aquaculture industry is fully developed in the Maldives".

  The sub-goals are as follows:

  - The technological development of aquaculture is optimized.
  - The extension services are adequate.
  - The management system is adequate.
  - The financial system is adequate.

- For Post-harvest and Value addition, the goal is: "The quality of fish catch and fish products is optimized".

  The sub-goals are as follows:

  - The quality of fish catches is optimized.
  - The value addition of fish products is optimized.
  - The legal and institutional framework is adequate.
  - Human resources correspond to the needs.

2.2.3 Guiding Principles

The SFDPIS represents a vision for sustainable development and management of the fisheries sector for the next decade, aimed at various levels of both public and private sector. It has been developed based on the following guiding principles.

a) Supporting the implementation of the SAP

The SFDPIS is a comprehensive document that defines the development, management and administration of the Maldivian fisheries for the period 2016-2025. The Plan is built on the vision and policies for the fisheries sector as set out in the current Strategic Action Plan (SAP) – 2014-2018 for the fisheries sector.

b) Encouraging Stakeholder Involvement

The involvement of the stakeholders (i.e. fishers, boat owners, processors, private sector, civil society, government institutions etc.) is crucial during each stage of the development of the SFDPIS, i.e. its formulation, implementation and monitoring.

Various stakeholders have been intensely involved in the formulation process of the SFDPIS. Mechanisms must be put in place to ensure their continuous participation along the following stages.

c) Promoting Community Development

Fishing and fisheries-related activities are still the economic backbone of most island communities in the Maldives; hence fisheries development and management programs have a profound impact on the livelihood of these communities. The projects of the SFDPIS are designed to benefit these communities and to contribute to the overall socio-economic development of the islands.

d) Enhancing Human Resource Development

The fisheries sector provides employment opportunities, not only for fishers directly involved in fishing, but also for a number of associate industries such as boat builders, engine repair and maintenance workers, fish processors and traders, ice plant operators, fuel providers etc.

It is essential for the sustainability and further development of the sector that human resources within all the segments be enhanced to address the immediate as well as the long-term needs of the sector.

A needs assessment for the fisheries administration and the marine research has been carried out recently. A comprehensive plan for recruitment of additional technical staff and capacity enhancement of the current staff needs to be finalised and implemented.

e) Enhancing partnership with other sectors

Even though MoFA is the responsible agency for the sustainable management and development of the marine resources in the Maldives, it will not be able to fulfil its mandate without the cooperation of and collaboration with other relevant institutions and agencies, such as the Ministry of Environment and Energy, Environment Protection Agency, Ministry of Defense and National Security, Coast Guard, Maldives Customs Service, Transport Authority, Ministry of Health, Ministry of Education etc.

Mechanisms will be established to strengthen participation of all relevant agencies in the decision making process related to sustainable management and development.

f) Giving due consideration to environment protection

The Constitution of Maldives recognizes that environmental protection is a human right. The country is a leading advocate of environmental protection in the international arena and has pledged to protect environment, work towards achieving carbon neutrality and reducing greenhouse gases.

The tourism and fisheries sectors, foundation of the Maldivian economy, account for more than half of the national employment, about two thirds of the national GDP and almost all export earnings. Both sectors rely on biodiversity and the protection of environment and sustainable management of the marine resources are crucial to both of them. The SFDPIS will ensure that environment is safeguarded in all its projects.

A preliminary Strategic Environmental Assessment (SEA) was carried out during the process of the SFDPIS formulation, which determined that an Environment Impact Assessment (EIA) will be required only for some infrastructure projects in the Aquaculture and the Post-harvest and Value Addition Sub-Sectors.

For all 4 sub-sectors covered by the SFDPIS, a preliminary assessment of potential negative impacts of the implementation of the proposed projects has been done and the respective counter-measures identified for the few projects that would be detrimental to environment. Screening for Environment Impact Assessment (EIA) / Environment Social Management Framework (ESMF) has to be conducted for each project before implementation.

g) Promoting Gender Equality

Historically, women in the Maldives have played an important role in the traditional fish processing industry (i.e. fish cooking, smoking and drying) at community level. Even though the number of women involved in such activities has decreased over the years, they still play an active role in some island communities.

Besides traditional fish processing, women are increasingly taking up economic opportunities offered by small businesses involving marine resources; thus, entrepreneurial cooperatives owned and managed by women exist in some atolls. These cooperatives produce and sell tuna-based products to other islands, to resorts and to Malé. Women are also employed in large-scale tuna fish processing factories. Finally, women are actively involved in the administration and management of the fisheries sector at central level (MoFA and MRC).

The SFDPIS addresses the promotion of women's participation in the fisheries industry, especially through the projects regarding quality control and technical development of fish processing industries, and family-based aquaculture such as sandfish farming.

CHAPTER 3 - CONTENT OF THE PLAN FOR EACH SUB-SECTOR

This Chapter defines the strategic approaches towards the sub-sector goals (Section 3.1), as described in the previous Chapter, taking into account the results of the participatory analysis of each sub-sector and results of the pilot projects implemented by MASPLAN (Annex 1). Priority projects supporting each approach are defined (Sections 3.2 and 3.3). The duration and approximate timing of each project are consolidated in the form of roadmaps (Section 3.4).

Figure 5 hereafter gives an overview of the flow entailing sub-sector analysis, approaches and priority projects towards achievement of the sub-sector goals and the development visions.

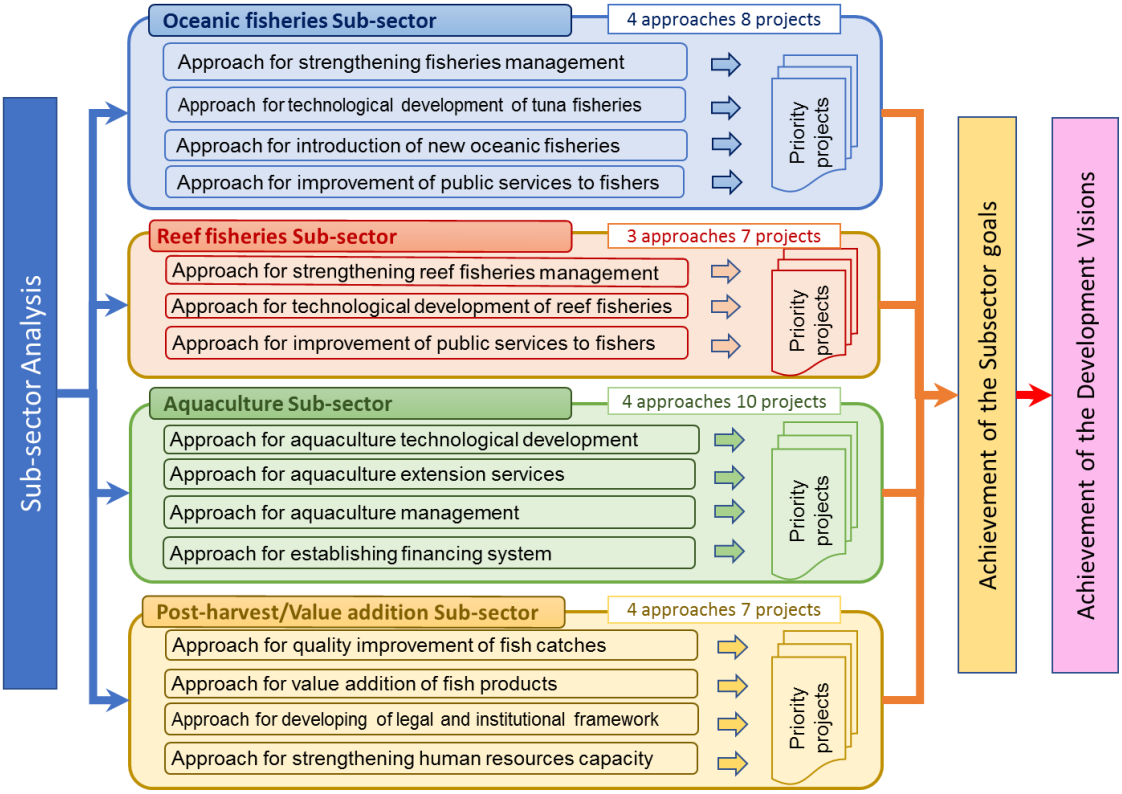


Figure 5 - Flow chart towards the achievement of the development visions, with outline of approaches and respective projects

3.1 Approaches

An approach is the way through which a given sub-goal of a sub-sector is achieved; it encompasses a set of priority projects to be implemented to that effect.

3.1.1 Oceanic Fisheries

The 4 sub-goals of this sub-sector are to be reached through the respective 4 approaches.

a) Approach for strengthening of fisheries management

In general terms, efforts will be exerted to strengthen all aspects of fisheries management of Maldives as a major country for sustainable tuna resource management and development in the Indian Ocean.

MCS system for the fisheries sector - While the MCS system has seen an overall improvement over the past decade, it requires further improvements to ensure the resources are used sustainably and to adopt international best practices.

The licensed component of the fishing fleet (i.e. fishing for export) is adequately monitored; vessels are required to be tracked via Vessel Monitoring System (VMS) and data on landings is collected through fish processors and exporters. Conversely, the unlicensed component of the fleet (i.e. for subsistence and for local sale) still needs to be brought under a similar regime to improve the monitoring of its landings.

The surveillance and enforcement of fisheries-related laws at sea is implemented through Maldives National Defense Force – Coast Guard. It is believed that there could be heavy seasonal poaching in Maldivian waters by foreign flagged vessels due to lack of capacity to monitor the EEZ. It is crucial to establish cost-effective, innovative MCS system to ensure that international requirements are fulfilled at minimum cost for the industry.

Fisheries management framework – The fisheries management framework for all fisheries,specifically for oceanic fisheries, requires further improvements, in particular to incorporate modern day fisheries management principles and approaches and to facilitate their implementation.

Awareness on resource management - Knowledge and awareness among fishing communities on proper resources use, regulations and compliance need to be improved.

Management of bait fish resources - Proper utilization and sustainability of bait fish is a major concern in the tuna fishery of the Maldives. A bait fish management plan has been prepared, and its implementation needs to be improved.

b) Approach for technological development of tuna fisheries

Utilization of live bait - The mortality rate of bait is high due to excessive stocking in the holding tanks of the fishing vessels and improper handling techniques; in addition, fishers harvest bait fish in excess of what is required for a fishing trip. These technical issues will be addressed as a way to improve the management of live bait.

Design of vessels - The technical design of vessels requires some modifications, aiming at improving the stability, ensuring better survival of live bait and more adequate fish conservation on board. In addition to addressing the bait fish issue, onboard systems that will ensure better handling of post-harvest catch such as ice making or RSW systems will be considered in the design modifications.

c) Approach for development of new oceanic fisheries

Utilization of unexploited fisheries resources - The Maldivian oceanic fisheries currently target skipjack, yellowfin and bigeye tuna. It is believed that the existence of unexploited fisheries resources within the Maldivian EEZ may foster the impetus for oceanic fisheries expansion. Further development of the fisheries sector is to be facilitated by exploring unutilized or under-utilized off-shore fishery resources, such as deep-sea squids and other high value species. Underdeveloped or unexploited fisheries resources will be investigated and possibly utilized to secure diversification of food supply and increase foreign currency earnings. Relevant studies, research and technical development will be undertaken to that effect.

Private investment - Financial mechanisms for the private sector to engage in such activities will be secured.

d) Approach for improvement of public services to fishers

Infrastructure to improve quality of post-harvest catch and Marinas - Public services to fishers will be improved. This encompasses namely the improvement of

infrastructures that support the fishery industry and the socio-economic environment of fishers, the provision of information about fishing grounds and technical development.

Priority will be given to building or improving ice making facilities for better quality of fishery products, and establishing "Fisher's Marinas".

3.1.2 Reef Fisheries

The 3 sub-goals of this sub-sector are to be reached through the respective 3 approaches.

a) Approach for strengthening of reef fisheries management

Coral reefs are fragile ecosystems that can be easily destroyed by human-induced activities and natural disturbances. Maldives needs a comprehensive and coherent reef resource management regime.

Maldives have an open access for reef fisheries. There are size limits to grouper fisheries and a quota system for the aquarium fisheries, which are loosely implemented. There is an increase in demand for reef fish with the expansion of tourism sector, local consumption and recreational fisheries and this might lead to negative impacts on the fisheries resource base.

Data collection and analysis - As statistical and scientific data is crucially needed for the design of appropriate fisheries management plans, the system for data collection and analysis of the diverse reef fisheries will be improved.

Legal instruments and compliance - Regulations for the various components of the reef fisheries need to be defined and / or adjusted. In some instances, the actual enforcement of existing legal instruments needs to be reinforced. In the particular case of grouper, the Government, on the basis of the scientific studies available and after consultation with relevant stakeholders, made the decision to limit sizes of grouper exports and to protect 5 grouper spawning areas for a period of 3 years; however, there are unverifiable reports of processing facilities purchasing fish lower than the size limits.

Resource management plans - Some management plans are already developed; they need to be reviewed and simultaneously, their proper implementation be ensured; others will be designed and implemented.

The capacity of stakeholders will be strengthened in reef fisheries resource management.

b) Approach for technological development of reef fisheries

Boat design - Reef fishing vessels do not systematically have adequate fish hold to conserve the fish. In particular, grouper fishing is usually carried out by small fishing vessels, not equipped and geared to implement proper post-harvest handling procedures, and as a result, there is a high mortality of grouper during the transportation process. In general terms, the characteristics of the reef fishing boats will be improved to allow for better quality of fish on board.

Awareness on good practices - Low interest of some fishers and fish buyers (including resorts) to maintain good quality is also an issue. The general need to increase awareness of all stakeholders (fishers, fish buyers, resorts and general public) on sustainable fishing and fish handling practices and to train them on how to implement these practices will be addressed.

c) Approach for improvement of public services to fishers

Infrastructure to improve quality of post-harvest catch and Marinas - The current infrastructure of the Maldivian fisheries sector is not geared specifically to the reef fishing industry. As a result, obtaining ice to preserve the post-harvest catch continues

to be a challenge for reef fish fishers in some areas. Therefore, public services to reef fishers will be developed through better access to ice to improve the quality of their catches.

In addition, the construction of "Fisher's Marinas" will improve the working environment of fishers and provide them with technical information.

3.1.3 Aquaculture

The 4 sub-goals of this sub-sector are to be reached through the respective 4 approaches.

a) Approach for aquaculture technological development

As aquaculture is not being commonly practiced in the Maldives, know-how on the basic technical aspects of the operation is lacking. Although most of the applicable technology has already been developed and is in use in other countries, much of these have never been tested in local conditions. As a result the private sector is reluctant to invest in this new business. Targeted programmes to test existing technology, refine them to local conditions and demonstrate them to the public is required

Overall technical development - Technical development suitable for the natural environment of the country must be a principal strategy for aquaculture development, at least in the short to medium term. The development of capacity to carry out aquaculture research and technology development, both in terms of infrastructure and human resource, is required.

The development and refinement of practical and environmentally sound aquaculture technology in addition to aquaculture production capacity is a priority area to facilitate immediate kick-off of the sub-sector. The introduction of subsidiary / supplementary activities such as production of feed and other inputs should be a long-term strategy.

Immediate efforts into the development of public infrastructure such as hatcheries or demonstration centres are required.

Establishment of mass seed production system - The long-term target for aquaculture development is to encourage private sector engagement in operating hatcheries and extension services. Establishment of facilities of significant scale is highly expected as centres of technical development, seed distribution and technical training for the private sector. Priority technical development includes establishment of mass seed production system and preparation of quality formula feed utilizing local materials.

b) Approach for aquaculture extension services

Training and demonstration facilities - In the short term, aquaculture extension services will need to be provided through state-owned facilities.

Furthermore, collaboration with international organisations such as the Southeast Asian Fisheries Development Centre (SEAFDEC) and the Network of Aquaculture Centres in Asia-Pacific (NACA) is expected to play a significant role in aquaculture technical extension.

Formal education system - The long-term goal for aquaculture technical extension is to incorporate / integrate aquaculture-related subjects / modules into the formal education system.

c) Approach for aquaculture management

Aquatic animal health management - The capacity for aquatic animal health management and monitoring, including relevant biosecurity considerations, will be developed. Aquatic health management services such as quarantine and diagnostic

services will be developed in addition to disease risk modelling and monitoring tools to support the regulation of the sub-sector and reduce impacts to the farmers due to disease transmission.

Institutional mechanism - A lot of effort will need to focus on the development of a coordinated, consistent and efficient regulatory process for the sub-sector. MoFA will use science-based information to ensure sound management, regulatory and permit decisions. These will include developing planning, monitoring and evaluation methods and technologies relevant to the commercial aquaculture operations.

d) Approach for establishing financial system

Encouragement of private sector's investment - Private sector will be encouraged to engage in aquaculture businesses through the establishment of an adequate, functional mechanism to support financing of aquaculture businesses.

In order to address the relatively high initial investments, properly designed and managed financing schemes need to be developed, with viable and bankable production, post-harvest, processing and product distribution models, and thorough financial feasibility of the business made available to interest groups.

3.1.4 Post-harvest and Value Addition

The 4 sub-goals of this sub-sector are to be reached through the respective 4 approaches.

a) Approach for quality improvement of fish catch

Handling techniques on board and use of ice - In addition to tuna quality improvement through the introduction of on-board handling techniques, activities to improve fish products supplied to domestic as well as resort markets will be carried out. Effective utilization of fish holds on board fishing vessels, further development of ice supply system and use of RSW system and establishment of technical extension system on fish quality control will be developed and implemented under this approach.

Currently, most fish traders buying skipjack tuna products from small-scale processors do not differentiate high and low quality; they do not offer any premium price for better quality products. Hence, there are no economic incentives for the fishers to adhere to better handling practices, namely using ice, and for the processors to implement adequate processing practices.

There is no incentive for yellowfin tuna fishers to practice proper post-harvest handling of the catch, as the various grades except for the rejected one are paid the same price by the large-scale processors. A market-oriented pricing mechanism needs to be implemented by these processors so that a higher price is paid for high quality fish.

b) Approach for value addition of fish products

Traditional processed fish - Traditional processed fish faces many quality issues and measures will be undertaken to address them. Preparation of quality standards for this type of products and dissemination of improved techniques will be conducted.

Katsuobushi - The production of high-value katsuobushi represents good opportunities for product diversification.

Fish marketing system - All actors of the value chain need to have access to information on prices, markets and product diversification.

c) Approach for improvement of legal and institutional framework

Hygiene control - In terms of maintaining safety and quality of fish and fishery products, Maldives is in compliance with a number of international standards for fish and fishery products for export.

Local food products have to register in Maldives Food and Drug Authority (MFDA) and to comply to the Regulation on the hygiene requirements of food production; however the implementation of this regulation is very weak as the mandate has been changing over the years from Health Protection Agency to MFDA, sometimes with the involvement of the City Councils.

Coordination between the processors and government institutions responsible for quality assurance needs to be enhanced and a comprehensive national regulatory program for traceability, quality inspection and control systems before and after harvest, during transport, storage, processing and export needs to be prepared and implemented.

Legal and institutional framework on quality control and hygiene standards for fishery products will be improved so as to strengthen relevant systems for quality control and monitoring of fresh fish and processed fish.

d) Approach for strengthening of human resources capacity

Training program for quality improvement - Besides the insufficient availability of ice and other services, fishers and traders lack of knowledge on quality aspects results in them handling and processing fish in unhygienic conditions, causing spoilage, contamination and eventual loss of income.

Although MoFA has been carrying out a number of programs to improve fish handling techniques, these programs are implemented on an ad hoc basis, according to availability of funds. It is necessary to secure funding to further strengthen the existing training program, targeting all the significant fish processing islands in a specified period of time and involving fishers, technical staff of processing companies and government officials.

Large-scale fish processors have invested heavily and expanded in recent years and the quantity of fish they handle has increased substantially. While the expansion has yielded benefits to the processors, these operators are also facing constraints in managing their business.

3.2 Priority Projects

A series of priority projects supporting each approach are presented in this section. The relation between approaches and projects is shown in a diagram for each sub-sector. Some priority projects involve various sub-sectors and so they appear in the respective diagrams. Each project is identified by its number, and detailed project descriptions are presented in the Project Summary of Annex 2.

3.2.1 Oceanic Fisheries

The outline of the priority projects of the oceanic fisheries sub-sector by approach is explained hereafter and the relationship between approaches and priority projects is shown in Figure 6.

a) Approach for strengthening of fisheries management

OF1. Improvement of MCS system

After the revision of the Fisheries Act, the MCS framework is strengthened and expanded, with the deployment of inspectors/observers and in cooperation with other implementing agencies.

OF2. Training on resource management

An appropriate resource management training program is set up, encompassing the establishment of a cooperation framework with relevant NGOs, the development of training material and the capacity development of trainers. Thereafter, practical training programs are implemented for fishers engaged in oceanic fisheries.

OF3. Review and implementation of bait fish management plan

Hindrance to tuna fishing due to shortage of bait is mitigated through effective management of the bait fish resources. This includes identification of the gaps in the current bait management plan, subsequent revision of this plan and its enforcement across the country.

b) Approach for technological development of tuna fisheries

OF4. Extension of improved live bait stocking system in pole-and-line fishery

Based on the results of the respective MASPLAN pilot project (see Annex1, PP1), the modified live bait tank associated with improved bait handling methods is extended among pole-and-line fishing vessels through awareness and training programs.

OF5. Development of a new masdhoni design

The standard design of the 5th generation fishing vessel ("masdhoni") will be developed and disseminated to fishers. It will incorporate advanced technologies such as the Japanese type bait tank, better stability, RSW system etc.

This approach will also include the projects AQ2 "Establishment of milkfish seed production facilities to provide bait" and PV1 "Extension of improved on-board handling in tuna handline fishery" (see Figure 8 and Figure 9 hereafter).

c) Approach for development of new oceanic fisheries

OF6. Promotion of private investment

Investment for new oceanic fishing activities such as longline and deep-sea fishing will be promoted among local investors after assessment of their financial feasibility. The project will assist the promotion of preferential investment policy from the Government and the preparation of business plans by the private sector.

OF7. Development of new deep sea fisheries (Diamondback Squid and other fishes)

The preliminary survey of the respective MASPLAN pilot project (see Annex 1, PP3) showed the existence of potential deep sea fisheries targeting not only demersal fishes but also Diamondback Squid, which has been confirmed as a new potential resource in Maldives. Based on such preliminary results, deep sea fisheries will be further investigated and promoted.

d) Approach for improvement of public service to fishers

OF8. Establishment of Fisher's Marinas

The existing plan by MoFA foresees the establishment of 4 Fisher's Marinas on major fishing ports.

This approach will also include the projects PV2 "Strengthening the capacity of ice making facilities" and PV4 "Improvement of fish marketing system" (see Figure 9 hereafter).

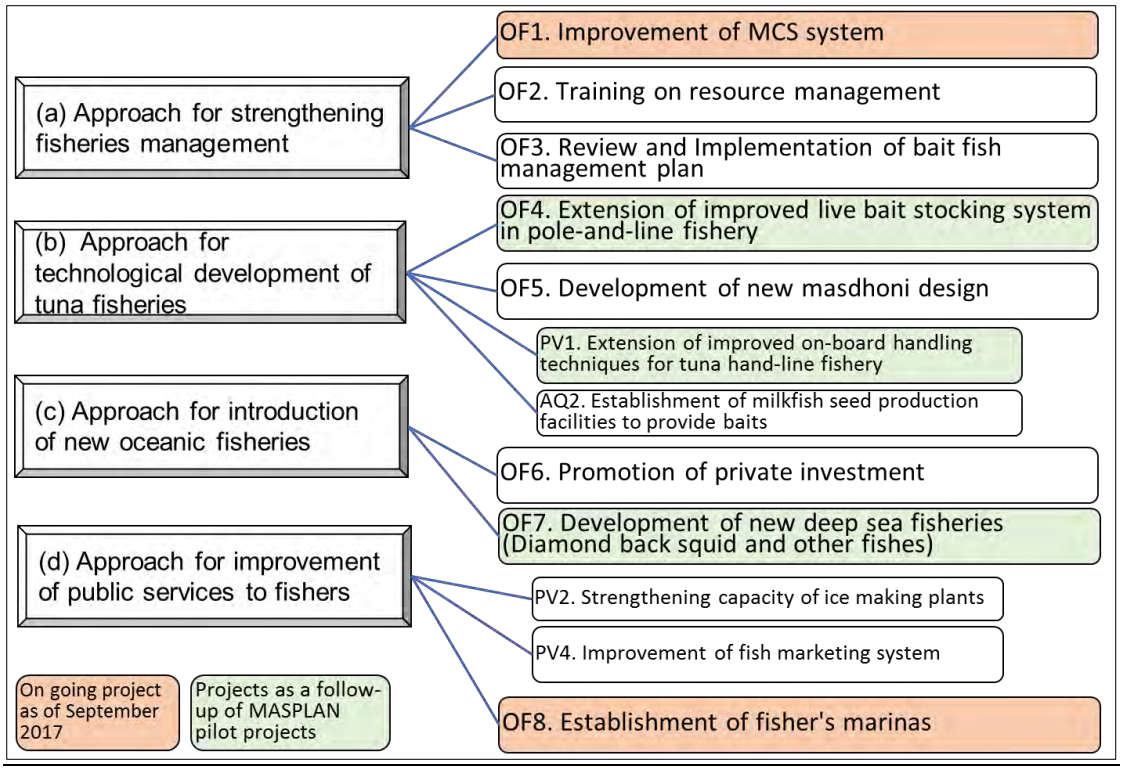


Figure 6 - Oceanic Fisheries - Relationship between approaches and projects

3.2.2 Reef Fisheries

The outline of the priority projects of the reef fisheries sub-sector by approach is explained hereafter and the relationship between approaches and priority projects is shown in Figure 7.

a) Approach for strengthening of reef fisheries management

RF1. Improvement of biological, socio-economic and statistical data collection and analysis system

A data collection system was tested with some resorts in North Malé Atoll as a MASPLAN pilot project (Annex 1, PP4). Based on the results of this pilot project as well as other projects currently implemented by MoFA, comprehensive data collection and analysis systems are developed for reef fisheries and implemented nationwide.

RF2. Improvement of relevant legislation about reef fisheries

Reef fisheries legislation is revised and completed for proper resource management. It implies that the revised Fisheries Act is enacted, and regulations for reef fisheries, grouper, aquarium fish, sea cucumber, lobster and sharks are reviewed or developed and implemented.

RF3. Enhancement of fisheries compliance/ enforcement

Cooperation between Marine Police, MoFA, Island and Atoll Councils and Environment Protection Agency (EPA) is strengthened, a licensing system for all reef fishing vessels is designed, implemented and functional and a Global System for Mobile Communications (GSM) tracking system for reef fishing vessels is implemented and functional.

RF4. Design and implementation of reef fisheries management plans

Fisheries management plans for reef fisheries, grouper, aquarium fish, sea cucumber and lobster are reviewed or developed and implemented. A National Plan of Actions for sharks is finalized and implemented and a management plan for these species is possibly developed.

RF5. Capacity enhancement on fishery resource management

Stakeholders such as boat owners, fishers, fish middlemen, tourists and the general public develop their skills on marine resource and environmental management through awareness and training sessions. Various types of training materials, e.g. on laws, regulations and enforcement will be prepared. Technical capacity of both MoFA and MRC staff will be improved to address reef fisheries resource management.

This approach will also include the project OF3 "Review and implementation of bait fish management plan" (see Figure 6).

b) Approach for technological development of reef fisheries

RF6. Improvement of boat design and equipment

Possible improvements on boat design / equipment for fish handling, particularly for live grouper fishing, and on ice / fish storage are identified; these improvements are subsequently implemented on a pilot basis then disseminated nationwide.

RF7. Awareness on fishing and fish handling techniques

Possible improved fishing and fish handling techniques to be introduced are identified, and subsequently awareness and training materials are developed in collaboration with the post-harvest and value addition sub-sector. Training sessions are conducted for concerned stakeholders.

c) Approach for improvement of public services to fishers

This approach will include the projects OF8 "Establishment of Fisher's Marinas", PV2 "Strengthening capacity of ice plants" and PV4 "Improvement of fish marketing system" (see Figure 6 and Figure 9).

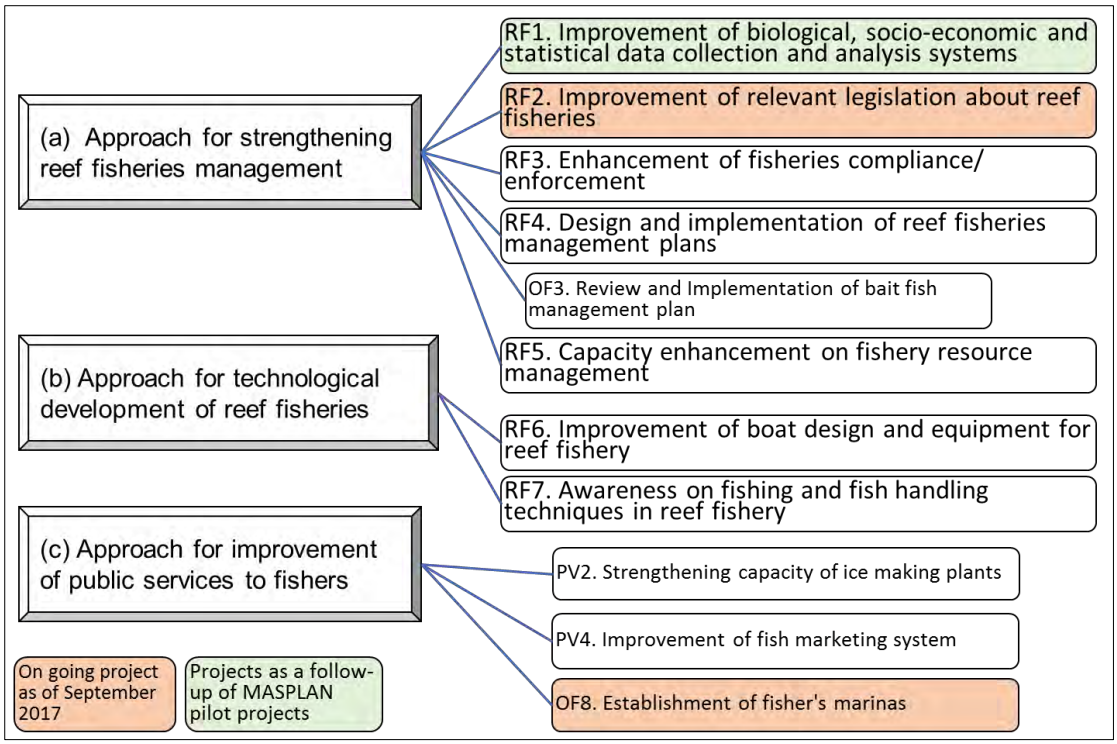


Figure 7 - Reef Fisheries - Relationship between approaches and projects

3.2.3 Aquaculture

The outline of the priority projects of the aquaculture sub-sector by approach is explained hereafter and the relationship between approaches and priority projects is shown in Figure 8.

a) Approach for aquaculture technological development

AQ1. Establishment of multi-species hatchery

The development of multi-species hatchery facilities will provide the required inputs in terms of seed, demonstration and extension services for grow-out operations. This will address the issue of broodstock for start-up grow-out operations.

AQ2. Establishment of milkfish seed production facilities to provide bait

The bait availability has been a recurrent issue for the pole-and-line fishery. The production of an alternative source of bait through successful aquaculture would cater to the need for bait and reduce the stress on the wild stocks of bait species.

AQ3. Development of domestic fish feed using by-product of fish processing

Feeding costs are expected to be among the highest costs of marine aquaculture operations. The production of aquatic feeds suitable for the target species, using local fishmeal produced at a low cost would considerably reduce the overall costs of aquaculture production. As a matter of fact, the tuna processing industry produces significant amount of waste which could be utilized for the production of fishmeal for aquaculture.

This project will aim to identify available resources and test locally produced feeds to assess their efficiency.

AQ4. Refinement of existing aquaculture techniques

The existing technology for seed production and grow-out production will be refined to better suit the Maldivian context; this is expected to improve production efficiency and possibly reduce the production cost of selected species. This project will be carried out at the newly-established multi-species hatchery as well as at the MTDF/MRC.

AQ5. Training and demonstration capacity building of MTDF/MRC

The capacity of existing facilities for mariculture such as MTDF/MRC will be upgraded to facilitate training and demonstration, through both infrastructure and human resource development. In addition, these facilities will carry out research on potential aquaculture species to be developed in the future.

b) Approach for aquaculture extension services

AQ6. Extension of potential mariculture techniques

Mariculture techniques developed through the research and development efforts and for which financial feasibility studies are conducted will be extended to the private sector. The research and development as well as training and demonstration facilities will contribute to the development of extension services.

AQ7. Promotion of aquaculture through formal education system

The existing level of awareness on aquaculture will be increased through the incorporation of aquaculture in the local education system, as in the case of capture fisheries.

c) *Approach for aquaculture management*

AQ8. Improvement of aquatic animal health management

Biosecurity levels will be ensured through the construction and operation of an aquatic quarantine facility; aquatic animal health management will be ensured through the construction and operation of diagnostic facilities and the implementation of aquatic health surveillance programmes.

AQ9. Strengthening institutional mechanism on aquaculture activities

Systems that allow for improved management of aquaculture operations, including monitoring mechanisms through the establishment of a certification programme, are set in place. Such certification programmes could either be adopted from an existing international scheme or formulated to fit the local requirements.

d) *Approach for establishing financial system*

AQ10. Development of financing system for aquaculture

This project will assess the existing financing mechanisms available for aquaculture and evaluate the possibility of developing a scheme suitable for the sub-sector. The project aims to establish a new investment platform on aquaculture for the private sector, and to investigate the banking policy and the Government policy.

This approach will also include the project PV4 "Improvement of fish marketing system" (see Figure 9 hereafter).

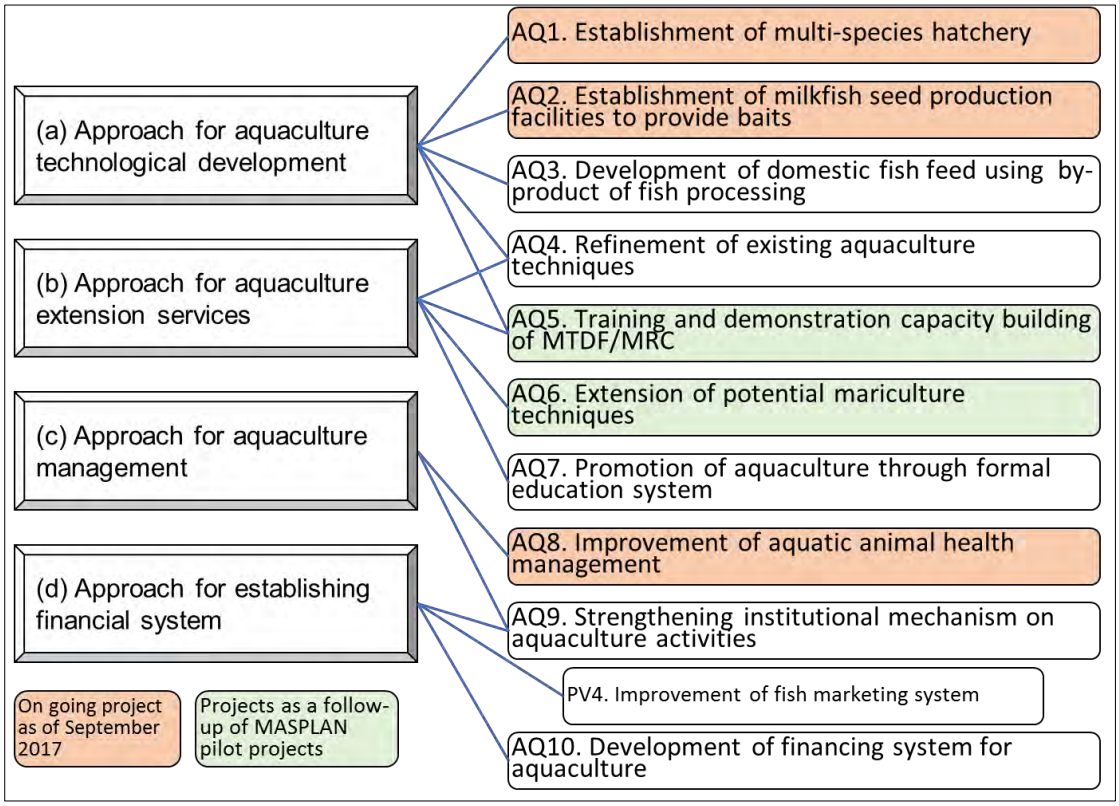


Figure 8 - Aquaculture - Relationship between approaches and projects

3.2.4 Post-harvest and Value Addition

The outline of the priority projects of the post-harvest and value addition sub-sector by approach is explained hereafter and the relationship between approaches and priority projects is shown in Figure 9.

a) Approach for quality improvement of fish catches

PV1. Extension of improved on-board handling techniques for tuna handline fishery

Modified yellowfin tuna on-board handling methods based on the results of the respective MASPLAN pilot project (Annex 1, PP2) are extended to handline tuna fishing vessels through an awareness and extension program. This project will be implemented in collaboration with the oceanic fishery sub-sector.

PV2. Strengthening capacity of ice plants

A feasibility study is completed for potential sites, as per their socio-economic and environmental conditions as well as their operation and management structure; subsequently the required ice plants are established. Demonstration on proper use of ice will be provided.

This approach will also include the projects OF5 "Development of a new masdhoni design for oceanic fishery", RF6 "Improvement of boat design and equipment for reef fisheries" and RF7 "Awareness on fishing and fish handling techniques in reef fisheries" (see Figure 6 and Figure 7).

b) Approach for value addition of fish products

PV3. Extension of quality improvement methods for traditional processed fish

Technologies on quality improvement of traditional processed fish in view of product safety, a topic which has been developed and verified through the respective MASPLAN pilot project, are extended among cooperatives / SMEs and individuals through training.

PV4. Improvement of fish marketing system

Based on the analysis of the current fish marketing system, an advanced market information service system will be implemented to improve the value chain of fishery products. Targets include local, resort and export markets.

PV5. Development of katsuobushi processing technology and facility

Appropriate technology and facility for small and medium-scale fish processors to produce katsuobushi will be developed and extended; it is expected that the products will be sold on the Japanese market.

This approach will also include the project AQ3 "Development of domestic feed using by-product of fish processing" (see Figure 8).

c) Approach for developing of legal and institutional framework

PV6. Development of minimum national standards / regulations for fishery products

The necessary minimum standards/regulations relevant to fishery products will be formulated and implemented.

d) Approach for strengthening human resources capacity

PV7. Establishment of a training system for fish quality assurance

A training system on fish quality assurance will be established for government officials, technicians of private companies and fishers.

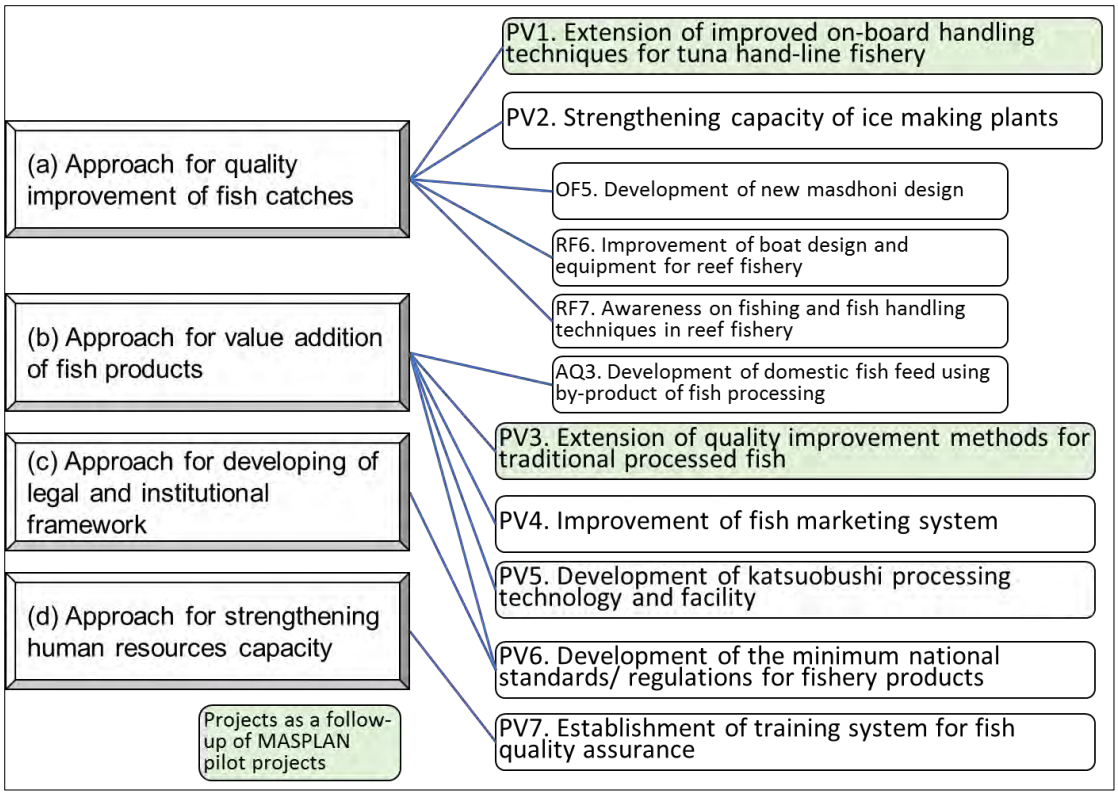


Figure 9 - Post-harvest / Value addition - Relationship between approaches and projects

3.3 General overview

Figure 10 gives a general overview of the priority projects, according to the various components.

Component \ Sub-sector	Oceanic Fishery	Reef Fishery	Aquaculture	Post-harvest and Value addtion
Fisheries Management	OF1. Improvement of MCS system OF3. Review and Implementation of bait fish management plan	RF1. Improvement of biological, socio-economic and statistical data collection and analysis system RF2. Improvement of relevant legislation about reef fisheries RF3. Enhancement of fisheries compliance/ enforcement RF4. Design and implementation of reef fisheries management plans		
Technological development	OF4. Extension of improved live bait stocking system in pole-and-line fishery OF5. Development of new masdhoni design OF7. Development of new deep sea fisheries (Diamondback squid and other fishes)	RF6. Improvement of boat design and equipment for reef fishery	AQ1. Establishment of multi-species hatchery AQ2. Establishment of milkfish seed production facilities to provide baits AQ3. Development of domestic fish feed using by-product of fish processing AQ4. Refinement of existing aquaculture techniques AQ6. Extension of potential mariculture techniques	PV1. Extension of improved on-board handling techniques for tuna hand-line fishery PV5. Development of katsuobushi processing technology and facility
Training and awareness	OF2. Training on resource management	RF5. Capacity enhancement on fishery resource management RF7. Awareness on fishing and fish handling techniques in reef fishery	AQ5. Training and demonstration capacity building of MTDF/MRC AQ7. Promotion of aquaculture through formal education system	PV3. Extension of quality improvement methods for traditional processed fish PV7. Establishment of training system for fish quality assurance
Public services	OF8. Establishment of fisher's marinas			PV2. Strenthening capacity of ice plants PV4. Improvement of fish marketing system
Legal and institutional framework			AQ8. Improvement of aquatic animal health management AQ9. Strengthening institutional mechanism on aquaculture activities	PV6. Development of the minimum national standards/ regulations for fishery products
Financing system	OF6. Promotion of private investment		AQ10. Development of financing system for aquaculture	

Legend: On-going project as of mid-2017 | Project as a follow-up of a MASPLAN pilot project

Figure 10 - - General overview of the priority projects by component

3.4 Roadmaps

Roadmaps for each sub-sector are shown in Figure 11 to Figure 14. Brief explanations are given hereafter.

3.4.1 Oceanic Fisheries

The roadmap for Oceanic Fisheries is shown in Figure 11 hereafter.

Following the results of the MASPLAN pilot projects, improved live bait on-board stocking system (OF4) and new deep sea fisheries (OF7) shall be largely extended during the early stage of the SFDPIS period, together with the bait fish management for the pole-and-line fishery (OF3). Simultaneously, the improvement of the MCS system (OF1) and the on-going fisher's Marina project (OF8) will be carried out.

Thereafter, the new masdhoni design (OF5) will be developed and extended nationwide.

Training of fishers is presently carried out on a regular basis. The knowledge accumulated through such activities will be consolidated into training material from 2020 onward, and then actually used on selected islands (OF2).

In a later period, based on the results of technical development, private investment for oceanic fisheries, particularly for longline targeting diamondback squid and deep sea fishing (OF6) will be encouraged.

3.4.2 Reef Fisheries

The roadmap for Reef Fisheries is shown Figure 12 hereafter.

The MASPLAN pilot project verified the effectiveness of the data collection system for reef fish catch from resorts. This system needs to be refined and expanded to be used routinely (RF1).

It is most important to ensure the revised Fisheries Act is endorsed officially and to develop relevant legislation under this Act (RF2). Similarly, since management plans for grouper and aquarium fish have been prepared, they have to be reviewed, officially announced (RF4) and enforced (RF3). Management plans for other specific fisheries, e.g. sea cucumber and lobster, shall also be prepared throughout the SFDPIS period (RF4).

In addition, the improvement of reef fish boat design will be carried out in order to improve the quality of the fish caught (RF6).

Based on the improvement of regulations, statistical data collection and boat design, training materials on fishery resource management and fish handling techniques will be prepared and used for practical trainings of fishers and other stakeholders (RF5 and RF7).

3.4.3 Aquaculture

The roadmap for Aquaculture is shown in Figure 13 hereafter.

MASPLAN carried out a pilot project at MTDF/MRC to assess the technical and financial feasibility of aquaculture for selected species in the Maldives. The results of this pilot project will be used in future extension efforts (AQ5; AQ6).

MoFA has already started the construction of milkfish seed production facilities (AQ2); this will be incorporated in the comprehensive project of WBG entitled "Sustainable Fisheries Resources Development Project (2017-2022) in which (AQ1) "Establishment of multi-species hatchery" is encompassed.

An aquatic animal quarantine facility and an aquatic health laboratory, which play a key role in managing biosecurity issues relating to the importation of live aquatic organisms

for aquaculture will be established (AQ8); a local feed is also expected to be developed to reduce the overall production costs (AQ3) in the mid- term of SFDPIS. Existing aquaculture techniques will be refined by MTDF/MRC as well as the said WBG project (AQ4).

In relatively long term, more attractive financing options are required to encourage new entrants into the aquaculture industry (AQ10). The establishment and enforcement of aquaculture certification systems (AQ9) is expected to be implemented after the aquaculture sector has kicked-off. In addition, the incorporation of aquaculture in the formal education system, as well as enhancing the human resource capacity in aquaculture through the development of vocational training programmes (AQ7) are expected to be in place toward the end of the SFDPIS period.

3.4.4 Post-harvest and Value Addition

The roadmap for Post-harvest and Value Addition is shown in Figure 14 hereafter.

Based on the results of the respective MASPLAN pilot project, awareness of both fish processors and consumers on preservation processes will be dealt with in the short term through (PV3) . At the same time, improvement of yellowfin tuna handling on board for export will be disseminated in cooperation with the oceanic sub-sector (PV1).

Then (PV6) and (PV7) will be implemented in the mid-term of the SFDPIS.

The use of ice will be further promoted for both oceanic and reef fisheries under (PV2). This project will be conducted as a long-term project to increase the ice supply capacity nationwide, identifying the current status of ice supply and building the necessary ice plants wherever needed.

(PV5) will be implemented as a way to support local fish processors to improve their profit. It is also crucial for fishers and fish processors to keep their motivation in fishery and develop their business in a sustainable way, with the support of a system which provides market information on local, resort and foreign markets; the project (PV4) will be launched at the final stage of the SFDPIS.

Figure 11 - Roadmap of the Oceanic Fisheries Sub-sector

Projects	Target area/site	Target group/ beneficiaries	Implementing bodies		Major indicators	Current SAP period			Under new National Development Plan							Remarks
			Responsible agency	Partner		2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	
OF1: Improvement of MCS system	Whole country	MoFA/ All oceanic fisheries	MoFA	FAO	Establish a mechanism to detect infringements to existing regulatory framework by 2020.	TCP/FAO						→ Continuation				Implemented based on results of the FAO project TCP/MDV/3501
OF4: Extension of improved live bait stocking system in pole-and-line fishery	Whole country	Pole&line fishers	MoFA/ MRC		Modification of in-board bait tank is carried out for more than 3 boats annually after 2019.	MASPLAN			Extension							Preliminary stage is implemented as pilot-project of MASPLAN
OF3. Review and implementation of bait fish management plan	Whole country	All oceanic fisheries	MoFA/ MRC		The new live bait fish management plan is enforced by end of 2020.											The bait fish management plan has already been drafted in 2013, but not yet launched officially.
OF7: Development of new deep sea fisheries (Diamondback squid and other fishes)	Whole country	MoFA/MRC	MoFA/ MRC		Deep sea fishing vessel of private sector start operation by 2022.	MASPLAN			Extension							Preliminary stage is implemented as pilot project of MASPLAN
OF5: Development of new masdhoni design	Whole country	All oceanic fisheries	MoFA /MRC		New standard masdhoni design is published by 2020.				Design		Extension					
OF2: Training on resource management	Whole country	All oceanic fisheries/ Staff in charges of local governments	MoFA/ MRC		Trainings for local fishers and communities are held 2 times annually from 2022.						Manual		Training			
OF6: Promotion of private investment	Male	Private sector	MoFA		Number of business plan application is increasing											Particularly for longline and deep sea fishing
OF8: Establishment of fisher's marinas	Whole country	All oceanic and reef fisheries	MoFA		80% of fishers use the facility and services by end of 2019.	On-going										Both for oceanic and reef fishery

Figure 12 - Roadmap of the Reef Fisheries Sub-sector

Projects	Target area/site	Target group / beneficiaries	Implementing bodies		Major indicators	Current SAP period			Under new National Development Plan							Remarks
			Responsible agency	Partner		2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	
RF2: Improvement of relevant legislation about reef fisheries	Whole country	Reef fishers, fish traders, resorts	MoFA/ MRC	FAO	• All legal documents are approved at government level.	TCP/FAO										A revised Fisheries Act has already been drafted in 2016 but not yet enacted.
RF4: Design and implementation of reef fisheries management plans	Whole country	Reef fishers, fish traders, resorts	MoFA/ MRC		• All Management Plans are legalized and implemented	Grouper										Grouper and aquarium fish management plans have already been drafted in 2011 and 2014, respectively, but not yet launched officially.
						Aquarium fish										
									Other species							
RF1: Improvement of biological, socio-economic and statistical data collection and analysis systems	Whole country	Reef fishers, fish traders, resorts	MoFA/ MRC	Resorts, MOT	• Proper data on reef fisheries is collated, analyzed and used for management purposes.	MASPLAN						→ Continuation				The Regenerate Project is being implemented, with a similar concept.
RF3: Enhancement of fisheries compliance / enforcement	Whole country	Reef fishers, fish traders, resorts	MoFA/ MRC	Marine Police, EPA	• All reef fishing vessels are equipped with GMS system and comply with e.g. licensing regulations		Licensing system									
									GMS system							
RF6: Improvement of boat design and equipment for reef fishery	Whole country, in particular atolls with live grouper fishing	Reef fishers and fish traders	MoFA/ MRC	Ship builders	• Mortality of fresh fish on board is reduced and overall quality of fish is improved			Design								Ice storage in the boat is an integral part of the project.
									Extension							
RF5: Capacity enhancement on fisheries resource management	Whole country	Relevant government officials/private individuals	MoFA/ MRC	M. of Environment / EPA	• The stakeholders are aware of proper resources and environment management				Material							
											Training					
RF7: Awareness on fishing and fish handling techniques in reef fisheries	Whole country	Reef fishers and fish traders, resorts	MoFA/ MRC		• The concerned actors of the reef fisheries sub-sector implement adequate and viable techniques				Material							
											Training					

Figure 13 - Roadmap of the Aquaculture Sub-sector

Projects	Target area/site	Target group/ beneficiaries	Implementing bodies		Major indicators	Current SAP period		Under new National Development Plan							Remarks
			Responsible agency	Partner		2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	
AQ6: Extension of potential mariculture techniques	Whole country/MTDF	Investors for aquaculture	MoFA/ MRC	anonymous donor	More than 4 private farms uses the developed aquaculture techniques	MASPLAN							→ Continuation			
AQ5: Training and demonstration capacity building of MTDF/MRC	MTDF	MoFA staff and private sector	MoFA /MRC	IFAD/FAO	More than 4 technical training courses are implemented annually at MTDF/MRC	MASPLAN					→ Continuation					As a part of pilot project of MASPLAN, technical training on sea cucumber seed production was carried out.
AQ2: Establishment of milkfish seed production facilities to provide baits	Gaafu Alifu Atoll and whole country	Aquaculture farms	MoFA/ MRC	WB	Milkfish seed production facilities are established at Matu Island, Gaafu Alifu Atoll											
AQ1: Establishment of multi-species hatchery	Gaafu Alifu Atoll and whole country	Aquaculture farms	MoFA/ MRC	WB	Multi-species hatchery is established and functions											This project was initially planed by IFAD but suspended.
AQ8: Improvement of aquatic animal health management	Hulhumalé	Aquaculture farms	MoFA/ MRC	IFAD	An aquatic animal quarantine facility is established and functions											Quarantine facility will be supported by IFAD
AQ3: Development of domestic fish feed using by-product of fish processing	Whole country	Aquaculture farms	MoFA													
AQ4: Refinement of existing aquaculture techniques	Multi-species hatchery and MTDF	MRC experts and private technicians	MoFA/ MRC	WB										→ Continuation		
AQ10: Development of financing system for aquaculture	Whole country	Aquaculture farms	MoFA?	M. of Finance/banks	Efficient and reasonable credit is available for investors on aquaculture											
AQ9: Strengthening institutional mechanism on aquaculture activities	Whole country	Aquaculture farms	MoFA/ MRC		The certification system is accepted by MoFA by 2023											
AQ7: Promotion of aquaculture through formal education system	Whole country	School teachers/children	MoFA/ MRC	M. of Education/schools	The aquaculture modules are approved by Ministry of Education											

Figure 14 - Roadmap of the Post-harvest/ Value addition Sub-sector

Projects	Target area/site	Target group/ beneficiaries	Implementing bodies		Major indicators	Current SAP period			Under new National Development Plan							Remarks
			Responsible agency	Partner		2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	
PV3: Extension of quality improvement methods for traditional processed fish	Selected target islands	Cooperatives, SMEs	MoFA		Technologies applicable to cooperatives and SMEs are identified and disseminated	MASPLAN										
PV1: Extension of improved on-board handling techniques for tuna hand-line fishery	Whole country	Tuna handline fishers	MoFA/ MRC		More than 10 boats improve their on-board handling methods in 2022.	MASPLAN						→ Continuation				The project will be carried out in collaboration with oceanic fishery subsector
PV2: Strengthening capacity of ice making plants	Whole country	Fishers (oceanic & reef), fish traders, resorts	MoFA		Location, number of ice plants withproduction capacity and capacity of operational and management body, Blueprints of Basic Design (B/D) and Detailed Design (D/D)				F/S	Implementation						
PV6: Development of the minimum national standards/ regulations for fishery products	Whole country	Fish processors, distributors, importers, etc.	MoFA	MoED, MFDA	Minimum National Standards/regulations developed and enacted											
PV7: Establishment of training system for fish quality assurance	TH. Hirilandhoo Island & L. Maamendhoo /Gan Island	Fishers, fish processing companies, Government officials	MoFA	Qualification Authority	1) Number of training courses 2) Program /curriculum for each training course 3) Implementation plan of MoFA 4) Number of participants for each training course							→ Continuation				
PV5: Development of katsuobushi processing technology and facility	L. Mandhoo	Small and medium-scale processors	MoFA		Number of katsuobushi processors using the technologies and facility.											
PV4: Improvement of fish marketing system	Whole country	Fishers, fish processors (small-scale and large)	MoFA		System implemented											

ANNEXES

Annex 1. Results of the Pilot Projects

Annex 2. Summary of the Priority Projects

Annex 1. Results of the Pilot Projects

Annex1. Results of the Pilot Projects

A total of 6 pilot projects have been carried out as part of the activities of MASPLAN, with the objective to preliminarily test and validate potential development methods. They were as follows:

PP1. Technical development and verification of live bait catch and holding for improving their survival rate

PP2. Technical development of tuna hand line on-board handling for fish quality improvement

PP3. Preliminary resource survey on availability of deep-sea resources

PP-4. Monitoring of fish supply to resorts and setting up of an eco-label certification

PP-5. Feasibility study on mariculture of selected species in Maldives

PP-6. Quality improvement of traditional processed fish

The results of those pilot projects were incorporated in the formulation of various priority projects in the SFDPIS.

Outline and major outcomes of each pilot project are shown below.

1) PP1. Technical development and verification of live bait catch and holding for improving their survival rate

The pole-and-line fishery, which is the core and the mainstream fishery in Maldives, requires live bait such as sprats and cardinal fishes. However, in recent years, with the increase in size of the fishing vessels and in distance to the fishing grounds, the quantity of bait fish required per fishing operation has been increasing. As the proportion of bait that dies in the tank before it is used is high, improving the survival rate and duration of the bait is important in terms of effective resource use and reduction of the vessel operation costs.

PP1 aimed to introduce new technologies to tackle this issue; it especially tested the effect of improving the structure of the live bait tank, as applied on Japanese fishing vessels (Fig.1.1 and Fig.1.2) and introducing a water scoop net (Fig.1.3). The project was implemented from April 2015 to March 2017, including the planning and preparation stage.

The purpose of PP1 was set as “Methods to improve the live bait survival rate in the tank on-board the vessel is developed”, and the Objectively Verifiable Indicator was “The survival duration of live bait in the tank on-board is doubled as compared to the current situation”. Nevertheless, satisfactory results relating to this indicator have not been clearly evidenced, which is possibly due to issues in the research method, and not linked to the new technology itself.

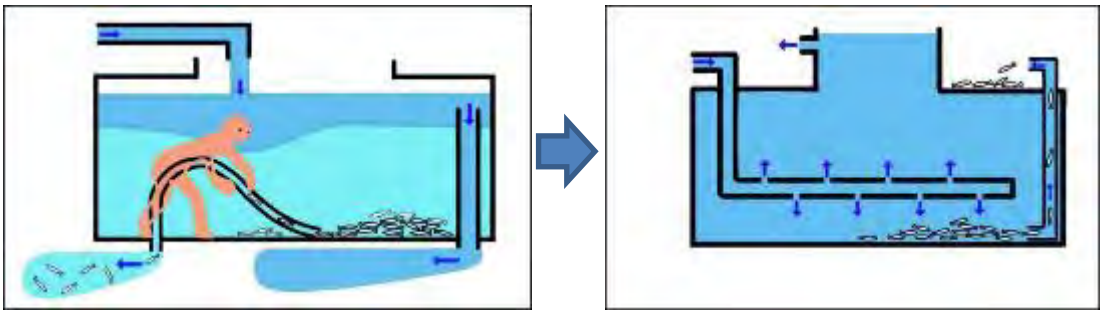


Fig 1.1 Concept of the current and the modified live bait tanks. Normal tank (left): Water input and drain are done from the surface. Dead baits are removed by a diver. Modified tank (right): Water flows in through an immerged tube and is drained out from both the bottom and the surface. Dead bait is removed automatically.

Fig. 1.2 Modified bait tank (at the center of the picture) and original tank (to the right)

Fig 1.3 Water scoop net operating on board the PP experimental boat

In PP1, the research on the live bait survival rate was conducted during the actual operation of the fishing vessel, taking various elements into consideration. However, it was difficult for the fishers of the vessel to fully understand the research method during the actual fishing operation, and insufficient data to assess the survival rate qualitatively was collected. In particular, in the case of the conventional live bait tank (used as a reference), it was very difficult to collect the dead bait accurately during the fishing operation, resulting in a significant underestimation of the figures.

However, although the results were not fully accurate, it is considered that the survival rate in the modified live bait tank was generally higher than that in the reference tank (Fig. 1.4). In general terms, the modified tank was more effective; the environment such as turbidity and turbulence of the water was obviously better than in the reference tank, and the bait fish, unstressed, remained grouped in a school. Furthermore, according to fishers' opinion, the bait fish was more lively as compared to the reference tank, even if it was stocked longer. Although it was not possible to evaluate quantitatively the effects as expected, the evaluation from the fishers who actually used the modified live bait tank was excellent.

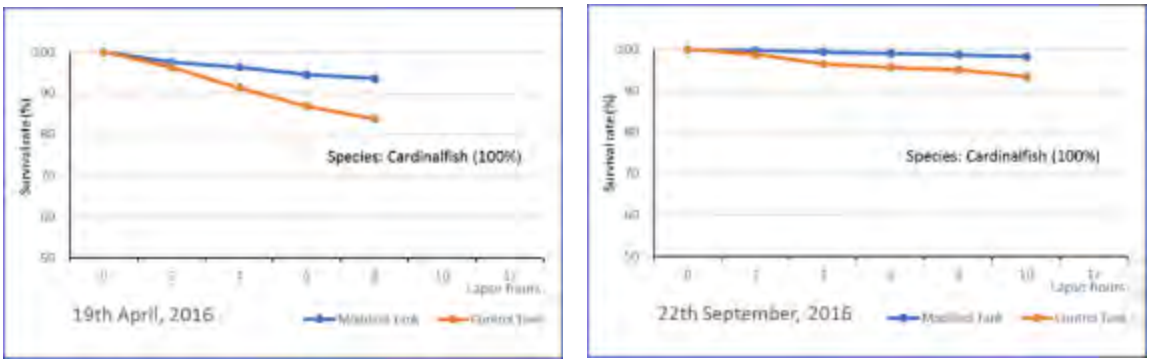


Fig 1.4 Comparison of the results of the live bait survival in a modified tank and a conventional tank (results of April and September 2016)

It is widely thought that those technologies could be widely adapted to pole-and-line fishing vessels in the Maldives. On the other hand, some reservations came up from the actual fishing operation, e.g. the small size of the tank hatch and the need to add an aeration system.

Based on these results, a priority project was included in the SFDPIS, i.e "Extension of improved live bait stocking system in pole-and-line fishery". It is desirable to implement promptly the extension activities from Addu Atoll, where boat builders gained experience through PP1 on how to improve the structure of the bait tank on-board.

2) PP2. Technical development of tuna hand line on-board handling for fish quality improvement

The yellowfin tuna handline fishery started in the early 2000s as a commercial scale activity and has become the second largest mainstream fishery after the pole-and-line fishery. ENSIS and other fish processing and exporting companies buy yellowfin tuna from local fishers and export mainly to the European market. However, the quality is insufficient and the proportion of high-quality fish sold as sashimi material is low, due to the fish handling method on board. Therefore, the development of technologies to improve the freshness of the catch is a big and urgent issue, which this pilot project (PP2) aimed to address. PP2 was implemented from May 2015 to March 2017, including the planning and preparation phase.

The project purpose of PP2 was set as "The quality of yellowfin tuna is improved through the development of fishing techniques and methods of on-board handling" and its Objectively Verifiable Indicator was "The rate of A-grade yellowfin tuna is increased on the experimental fishing vessel(s)".

Both the electric tuna shocker for stunning the hooked fish and the "*Irabu* method" (Box 2.1) were introduced to improve the post-harvest fish quality. Both methods are applied in the Japanese tuna fishery.

Box 2.1 : The "*Irabu* method" for *Yake* prevention

Yake is the phenomenon of deteriorating tuna meat (it looks like burned meat), which appears when the inner body temperature of tuna increases after strenuous movements during the catch. It happens frequently in high water temperature areas. The problem of *Yake* has been for long a critical issue in Maldives, as fish with *Yake* commands very low prices or is even rejected by the processing companies.

The same problem previously occurred in Okinawa, Japan, under similar sea and environment conditions; the *Irabu* Fisheries Cooperative Association developed a method to prevent *Yake* named the "*Irabu* method". This method is quite unique as compared to the traditional one: the fish is not killed after it is caught; it is directly put into cold water so that the inner body temperature of the fish cools down through natural gill respiration and blood circulation. The Okinawa Fisheries Research Center verified the effectiveness of the "*Irabu* method", as documented in publications in 2002.

Overall, the pilot project did not show clear differences in the grade composition of the catches, whether tuna electric shocker was used or not, although the shocker proved effective to haul hooked fish on board (Fig. 2.1).

Fig 2.1 Training on use of tuna electric shocker on board the

On the other hand, the fishes handled by the "*Irabu* method" showed grades significantly superior to those of the reference (i.e. under the normal procedures in the Maldives) (Fig. 2.2): the grades were A, B+ and B, with no cases of C and R (rejected), while the reference showed a wide range of quality grades, including C and R. It was therefore validated that the "*Irabu* method" was an effective solution to improve the quality of tuna catches.

However, even though the "*Irabu* method" was applied, it appeared that the highest (A+) grade (Sashimi grade for export to Japan) was difficult to achieve.

In order to disseminate these technologies and equipment, the project entitled "Extension of improved on-board handling techniques for tuna hand-line fishery" was included in the SFDPIS.

The fact that the purchase price of the catches is not linked to the grades (grades A to C get the same price) has been subject of a long-standing discussion between

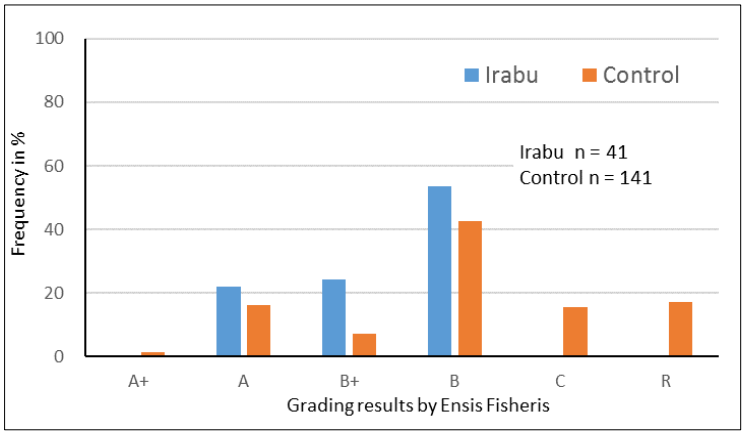


Fig 2.2 Grading results of yellowfin tuna caught by the experimental vessel modify Ensis Fisheries in horizontal scale
(Data combined from all four monitoring results from Nov 2016

the Government, the fishers and the processing industry. It is necessary to examine further how to overcome this crucial issue.

3) PP3. Preliminary resource survey on availability of deep-sea resources

The fisheries sector of Maldives is so far extremely dependent on skipjack and yellowfin tuna resources. However, taking into account the recent declining tendency of catch volume of skipjack tuna, fisheries diversification is an urgent issue. In addition, considering the remarkable growth of the tourism industry and the global Japanese food boom, there is a high demand for high value sea food products from the Maldives.

The project PP3 aimed at verifying the availability of untapped deep-sea resources for future exploitation and diversification of the oceanic fisheries. It has been implemented from October 2015 to March 2017, including the basic data collection survey. The purpose of the project was set as "Availability of untapped deep-sea resources is assessed by a preliminary resource survey"; a series of fishing tests were carried out using new fishing gear introduced from Japan.

The targeted species of PP3 were Diamondback Squid (DBS) and deep-sea bottom fishes. As DBS was not known in the Maldives, there was no information to decide on the survey period and area; to solve this issue, a basic information survey about the sighting of DBS egg mass was implemented and information on 41 sightings of eggs, in many locations nationwide, was collected.

The survey indicated that DBS probably spawns in the Maldives; the possible spawning areas and seasons were assessed based on the distribution patterns of eggs observed. The areas and season of the resource survey were determined based on this analysis. Regarding the deep-sea bottom fishes, as their distribution is in principle quite large in the Maldives, it was decided to operate the fishing tests near the survey areas of DBS.

Fig. 3.1 A harvest scene of DBS

Fig. 3.2 First catch of DBS in Maldives (November 14, 2016)

The DBS resource survey was implemented for 2 weeks in November 2016 and 3 weeks in February-March 2017, in the whole area of Maldives except for the southern part, and a total of 59 DBSs were caught during the survey (Fig. 3.1). This was the first official record of DBS catch in the Maldivian waters (Fig. 3.2). It is assumed that DBS matures between November and

February-March, considering the differences of average individual size (Fig. 3.3) and gonad weight (Fig. 3.4).

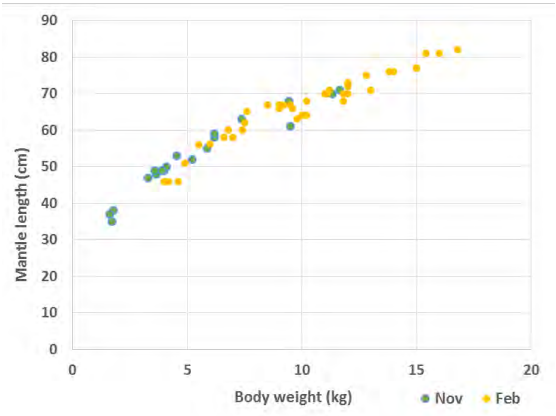


Fig. 3.3 Relation between mantle length and body weight of DBS caught in November 2016 and February-March 2017

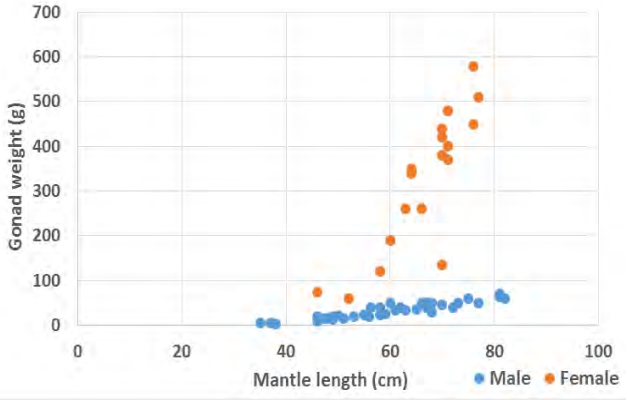


Fig.3.4 Relation between mantle length and gonad weight of DBS

As regards to the deep-sea fish resource, the experimental fishing survey was implemented from February to March 2017, using only nautical and electronic charts to decide on the operation points because of the insufficient capacity of the available echo-sounder. Despite this limitation, 14 species of deep-sea fin-fishes such as groupers and snappers were caught during the 8 trips of the resource survey.

Using the DBS caught by PP3, various activities were planned by MoFA, such as advertisement through media, a tasting session in collaboration with Chef Guild of Maldives and the demonstration of DBS fishing as an awareness activity during the "Fish Camp" organized for school students.

From these results, the project named "Development of new deep sea fisheries (DBS and other fishes)" was set up as a priority project in the SFDPIS.

4) PP4. Monitoring of fish supply to resorts and setting up of an eco-label certification

The insufficiency of the catch data collection had been identified as a priority issue to be tackled, linked to the overall increase of the fishing effort on the reef fisheries resources. The SSWG decided to implement the Pilot Project (PP4) focusing on the monitoring of reef fisheries use by the resorts.

The project purpose was "The basis for proper monitoring of reef fisheries resources is set up with the active participation of the resorts and an eco-label certification is designed as a tool for their promotion, in North Malé and Baa Atolls", which encompassed i) setting up the basis for proper monitoring of reef fisheries resources on a continuous basis; ii) stimulating the active participation of the resorts in fisheries resource monitoring, providing them with an eco-label

certification as a tool for their promotion; and iii) improving awareness of the resorts' clientele, local fishers and fish middlemen in proper use of the fisheries resources.

The level of achievement of the various outputs is summarised as follows:

In spite of initial contacts established by MoFA with the Ministry of Tourism, the link between the two institutions, relating to PP4, has not been established yet on a routine basis, due to insufficient follow-up by the Ministry of Tourism. However, a significant number of resorts in the selected areas were contacted within the PP, and one of them was particularly responsive ever since the implementation of the system.

The data collection system to be used by the project has been adapted from the one implemented by MRC in recent years. The actual implementation of the system by the resorts logically proved to be the more cumbersome part: there was a poor response from some contacted resorts and simultaneously MoFA and MRC staff were not able to dedicate sufficient time to this endeavor. Results regarding data collection on reef fish supply from one resort within PP4 are presented in Fig. 4.1.

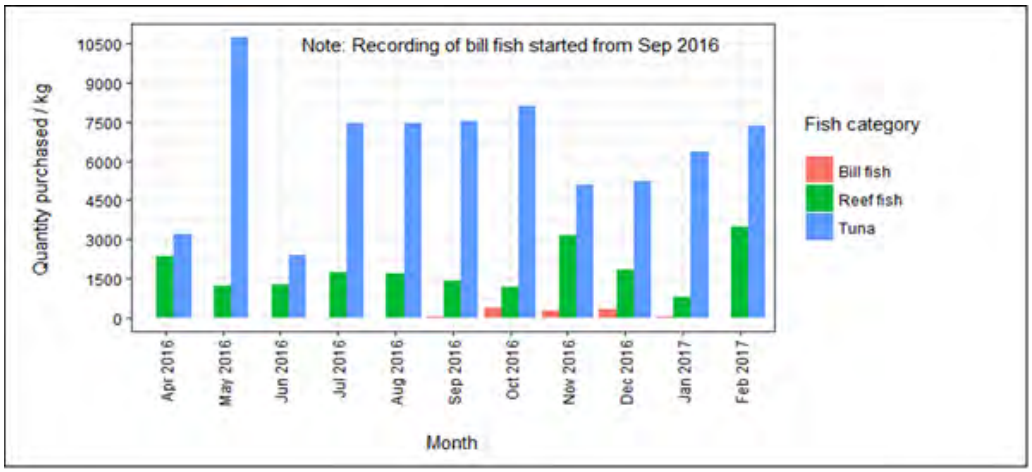


Fig. 4.1 Results of data collection from a resort in North Malé

Apart from the field work with resorts, fishers and fish middlemen, Guidelines on Best Fishing and Fish Handling Practices, in particular for Reef Fisheries, have been prepared within the project; the respective brochures will be produced and disseminated to resorts and professional fishers; subsequently, they will be translated into Dhivehi, printed and distributed. A sample page of these Guidelines is presented in Fig. 4.2.

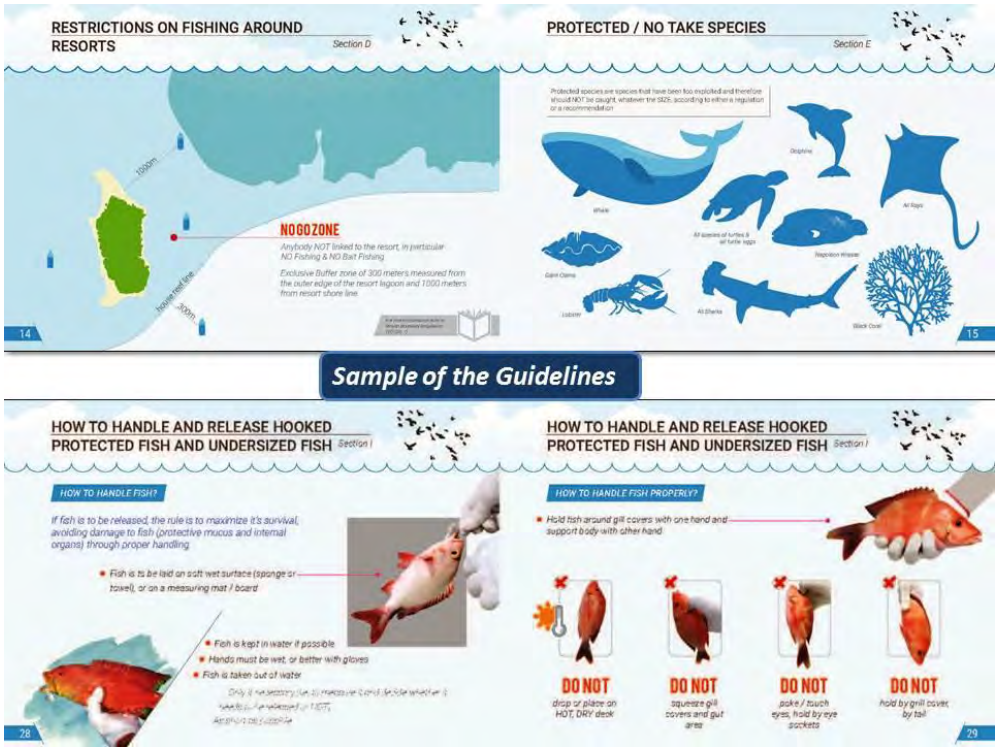


Fig. 4.2 Sample pages of the Guidelines on Best Fishing and Fish Handling Practices (2017)

An eco-label scheme for resorts was expected to be designed but was not pushed forward due to the slow pace of implementation of the data collection system as such.

Overall, motivation of the resorts to participate in the data collection system is not implicit and can only be ensured through close interaction and communication between MoFA / MRC staff and the various persons in charge at resort level. However, the PP has shown that it is possible to build up this motivation, as some resorts responded positively and have been implementing the data collection system with dedication and success. In addition, the PP made it clear that other elements of the reef fish value chain, i.e. major fish middlemen and possibly, fishers themselves, can be instrumental for the implementation of this system.

It is believed that the concept of eco-label for resorts is still valid; it can be developed as more resorts adhere to the data collection system, as a reward for their active participation therein.

As a follow-up of this PP, a priority project has been designed under SFPDIS as “Improvement of biological, socio-economic and statistical data collection and analysis system” within the “Approach for Strengthening Reef Fisheries Management”; in addition, the Guidelines prepared within PP4 will be utilized as a tool for dissemination within the Project “Awareness on fishing and fish handling techniques in reef fishery” of this Plan.

5) PP5. Feasibility study on mariculture of selected species in Maldives

Various technical studies about seed production and grow-out of grouper (Brown-marbled Grouper, *Epinephelus fuscoguttatus*) and sea cucumber (Sandfish, *Holothuria scabra*) have been carried out at the Mariculture Training and Demonstration Facility (MTDF) of MRC, MoFA. In addition, the Mariculture Enterprise Development Project (MEDeP), co-funded by IFAD, currently provides financial and technical assistance for aquaculture development. However, it is clear that information about the economic and financial feasibility of aquaculture is still insufficient.

The pilot project (PP5) was formulated to examine the feasibility of aquaculture, not only through the review of latest references on aquaculture but also through a practical rearing experiment (for sandfish only) and overseas technical training of counterparts. The purpose of this pilot project was set as "A strategy for mariculture development in Maldives is refined".

In terms of technical training for capacity development of counterparts, a total of 3 technical staff of MTDF attended in April 2016 a training course in SEAFDEC, the Philippines, entitled "the sandfish seed production, nursery and management". Based on the technologies learned, the seed production method at MTDF has been greatly improved. In addition, a study trip to Japan on grouper culture was conducted in July 2016 for 5 persons.

Through those training activities, the latest information about aquaculture techniques and the market situation in Southeast Asian countries has been gathered. In addition, the latest information on sandfish culture developed in the Maldives was collected by on-site reconnaissance surveys. All this information was compiled into a technical report, named "Applicable method of groupers and sandfish culture in Maldives" as an output of PP5. The report will be a key reference for further technical examinations and verification studies.

In order to observe the advanced sandfish culture practice, a study tour was conducted in November 2016 in Vietnam, which is known as the leading sandfish producer in the world and is considered as a potential competitor in the international market. However, it appeared that sandfish aquaculture in Vietnam is carried out merely as a by-product of Babylon snail culture in earthen ponds and that the target market is mainly national; this implies that cultured sandfish in Maldives will not compete with that of Vietnam. Expansion of sandfish aquaculture is expected in the country.

The outline of experimental rearing of sandfish at MTDF is shown in Fig. 5.1 and 5.2. The experiment was carried out from February 2016 to February 2017. The objective was to assess the technical feasibility of bottom-set cages for

Fig. 5.1. Juvenile sea cucumbers being stocked in bottom-set cages deployed in the lagoon

juvenile sandfish with feed input, a method which aims to develop aquaculture in shallow lagoons. Based on the results of monitoring of survival and growth in cages, it is assumed that this method is adoptable to shallow and rocky lagoons common in the Maldives. Detailed results were compiled in a technical report[1].

Based on all the information obtained through the pilot project, the financial analysis of grouper culture and sandfish culture was carried out on the basis of different scale model facilities.

In the case of grouper, the minimum feasibility model was for an 8-cage facility, and the profit increases with the scale of the facility (Fig. 5.3). On the other hand, sandfish grow-out culture in pen showed a clear economic feasibility, even with one pen (24m x 24 m).

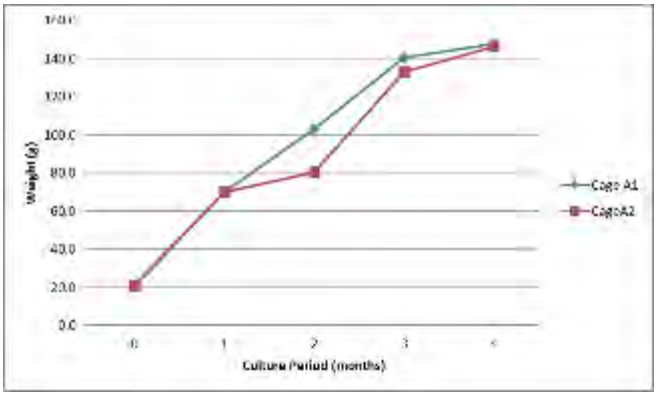


Fig. 5.2 Mean monthly growth of sandfish in bottom-set sea cage culture in shallow lagoon. Improve legibility of horizontal and vertical scales; clarify legends A1 and A2

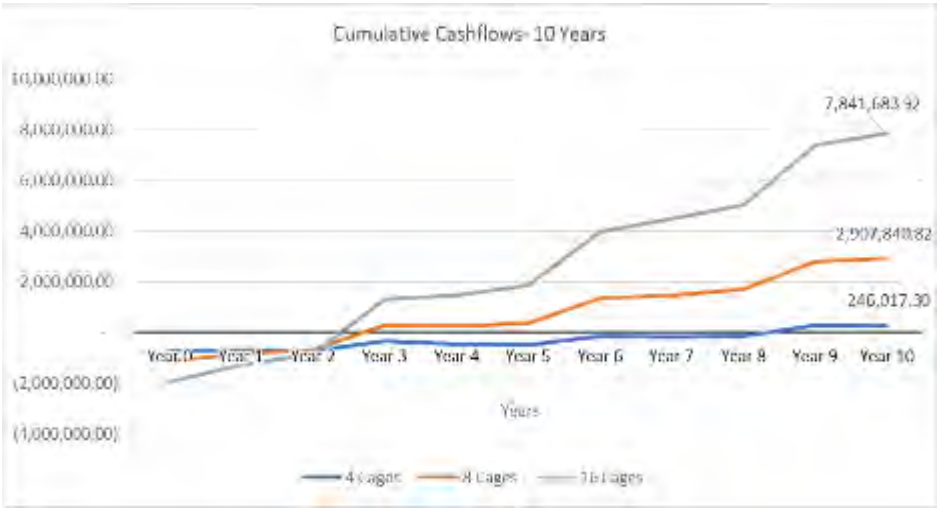


Fig.5.3 Cashflow analysis of grouper aquaculture for different scales of facilities Indicate unit of vertical scale (MVR); title on top to be removed; round up numbers (no need for decimals)

For future development of aquaculture in Maldives, a project funded by the World Bank has been launched in April 2017; it foresees in particular the construction of a multi-species hatchery for distribution of seeds to the private sector as well as for continuous technical development. The results of the pilot project will be quite instrumental for such a project.

[1] Pilot Study on Grow-out Culture of Sandfish (*Holothuria scabra*) in Bottom-set Sea Cages in Lagoon; Ahmed.H, H. Shakeel, S. Naeem and K. Sano (2017)

6) PP6. Quality improvement of traditional processed fish

In recent years, consumers' awareness on food safety has increased in the Maldives, especially in the urban areas. Vacuum packaged *valhoamas* has recently become popular on the local market, and consumers are aware it is safer than the traditional presentation. Packaged products are not homogeneous, as some have high moisture content whereas others are quite dry. Mold often appears in the packages as well as gas originating from an outbreak of anaerobic bacteria. Both mold and bacteria are a threat to human health and therefore a solution to this quality issue is strongly required. There are no official quality standards for production of *valhoamas;* large-scale processors conduct quality control according to their own standards, whereas medium and small processors do not conduct any quality control, which represents a risk in terms of food safety.

The pilot project (PP6) was therefore implemented with the purpose "The quality of traditional processed fish (*valhoamas*) is improved".

PP6 was conducted for about eight months, between February 2016 and October 2016. The project introduced a simple heat sterilization technique after vacuum-packaging, which improves the quality of vacuum packaged *valhoamas* and sets up the basis for the expiry date of the products. The experiment concluded that the product can have a shelf-life of 2-3 months at room temperature, if heating after packaging is done for 40-45 minutes in hot water at 85-90 degree Celsius. However, this result could be achieved only in the case of a product with low moisture content (water activity <0.94).

In PP6, the quality control of the products was done at the quality control room of the project, established in MIFCO Khoodhoo plant; comparative analysis was made between vacuum packaged (but non-heated) *valhoamas* collected from various sources including Malé market, and heated ones produced by the project. Among the non-heated products, some showed mold outbreak and a high bacterial count (> 10^6), in some cases with *E. coli*, as early as after a couple of weeks from the date of production (Table 6.1). On the other hand, the measured parameters of the heated products were stable even after two-three months from the date of production, except in the case of products with high moisture content (water activity>0.94).

Table 6.1 Storage test of heated and non-heated *valhoamas* (Aw.0.91) - bacterial count

Sample	Storage Period		
	0 days	60 days	90 days
Heated Product	(－)	(－)	(－)
Non-heated product	7.3×10^4	2.8×10^5	Mold

(－) : Bacteria wasn't identified in 10 times dilution

Mold : Mold was observed on the surface of *Valhoamas*

NB : Samples were placed at room temperature

Fish processors gained knowledge on technologies to improve traditional processed fish. Members of Gemanafushi Fishery Cooperative and small-scale processors in Gemanafushi Island, others located near MIFCO plant in Khoodhoo, Gaaf Alif Atoll (Fig. 6.1) and small-scale

processors in Maavha Island, Laamu Atoll were trained on the simple heat sterilization technique introduced by the project.

Fig. 6.1 Technical guidance on heat sterilization for small processors in Gemanafushi Island

Some small-scale fish processors have since then put this knowledge into practice. MIFCO actually produced and sold heated vacuum packaged *valhoamas* to see consumers' response.

An extremely high content of histamine is often verified in *rihaakuru,* which represents a critical quality issue. Histamine content was analyzed by the project on samples of both *valhoamas* and *rihaakuru*. The results showed that histamine content of many samples of *rihaakuru* exceeded 50ppm per gram, i.e. the maximum allowable value regulated by the national standard; in particular, the histamine content for repacked *rihaakuru* tends to be higher. As for *valhoamas*, the histamine content of the products with a large number of identified bacteria tended to be higher. It was inferred the histamine was accumulated by bacterial increase during the processing process of *valhoamas.*

As guidelines to produce safe *valhoamas.* two manuals, "Manual for Heat Sterilization" and "Manual for analysis on quality of *Valhoamas*" were completed based on the results of the pilot project.

The following two projects have been included in the SFDPIS to consolidate and expand the results, outcomes, and lessons learnt from PP6, 1) "Extension of quality improvement methods for traditional processed fish" and 2) "Development of minimum national standards for fishery products".

Annex 2. Summary of the Priority Projects

OF 1: Improvement of MCS system

Target Area: Whole Country
Target group: MoFA/ All oceanic fisheries
Project period: 2016 – 2020

Narrative Summary	Objectively Verifiable Indicators	Means of Verification
Overall Goal Responsibility for international MCS framework is fulfilled.	• IOTC requirements regarding to MCS are achieved by 2025.	• IOTC annual report/ minutes of annual conference
Project Purpose Improved MCS system following the revised Fisheries Act is implemented.	• Establish a mechanism for effective infringements to existing regulatory framework by 2020.	• Report by Fisheries Management Section, MoFA
Outputs 1. Cooperation framework of MCS implementing agencies is strengthened. 2. Installation of VMS on oceanic fishing vessels is promoted. 3. Current observer program is reinforced 4. Reporting coverage of logbooks is increased	• From 2017, regular meeting of MCS implementing agencies is held more than 1 time/ year. • 100% of licenced fishing vessels equipped VMS by the end of 2020. • Planned number of observers is allocated by the end of 2020. • All licenced fishing vessels record and submit all required data including by-catch annually by 2020.	• MoFA annual report • Statistical report of fish by-catch

Activities

1-1 Carry out regular meeting of MCS implementing agencies that including MoFA, Custom office, Coast Guard, Immigration and Police.
1-2 Hold the MCS Implementation Committee attending by minister level of MCS implementing agencies.

2-1 Introduce VMS which has an economical/technical advantage being proved by FAO project (TCP/MDV/3501) through various communication channels such as seminar, exhibition, booklet, etc.
2-2 Provide on-site technical assistance

3-1 Prepare deployment plan of the inspectors/observers to fishing vessels and fish landing ports.
3-2 Recruit inspectors/observers and train them in terms of lectures and on-board practices
3-3 Hold meeting of longline boat owners to build understanding of necessity of data collection and monitoring
3-4 Revise the plan at practical level
4-1 Implement awareness program

Inputs (indicate the budgets, if possible)

Maldives	Partner/donor
Personal a. Project coordinator, MoFA Fisheries Management Section staff b. MoFA legal officer c. AG office staff d. Officer in-charge of each MCS implementing agency Equipment and others a. Necessary costs of expanding VMS to fishing vessels b. Arrangements for any related meetings	Personnel a. MCS/VMS expert for training inspectors and observers Equipment and others a. Costs to train inspectors and observers b. Any necessary materials and equipment for the training

Special remarks (Important assumptions, , project sustainability, etc)

- This project shall be implemented based on the results of the FAO project (TCP/MDV/3501) that including enforcement of the revised Fisheries Act which provides MCS framework.
- MoFA has an observer program but not implemented at present

OF 2: Training on resource management

Target Area: Whole country
Target group: All oceanic fishers and local government staffs
Project period: 2021 –2022

Narrative Summary	Objectively Verifiable Indicators	Means of Verification
Overall Goal The knowledge on fisheries resource management is disseminated to the general public.	• Increase ratio of population who have adequate understanding on fisheries management.	• Reports on public-opinion research in 2021 and 2024
Project Purpose Training program about resource management in oceanic fisheries is implemented in cooperation with NGOs	• Trainings for local fishers and communities are held 2 times annually from 2022.	• MoFA annual report
Outputs 1. Cooperation framework between MoFA and relevant NGOs is developed.	• Agreement on collaborative training implementation is exchanged between MoFA and NGOs by end of 2021.	• Project reports • Training manuals
2. Trainers from NGOs are trained on resource management	• More than 2 candidate trainers of NGO attend capacity building training course of MoFA by 2022.	
3. Training materials are developed	• The training materials are approved by MoFA by 2022.	
4. Training programs are implemented	• Mobile trainings program is available	

Activities

1-1 Establish consultation committee among MoFA and relevant NGOs to plan training program framework
1-2 Discuss practical cooperation means at the committee meeting
1-3 Build consensus with NGOs about co-implementation of training program

2-1 Develop capacity building program for candidate trainers from NGOs.
2-2 Implement the training program for candidate trainers by MoFA.

3-1 Review existing training materials such as text books and videos
3-2 Prepare updated training manuals suitable for Maldives

4-1 Develop training program such as "island-based mobile training" for local fishers and communities
4-2 Implement the program

Inputs (indicate the budgets, if possible)

Maldives	Partner/donor
Personal a. MoFA Fisheries Management Section/ Training Section b. MRC members c. Trainers from NGOs Equipment and others a. Necessary arrangement to hold consultation committee meetings and trainings.	Personnel a. Fisheries management expert (6 M/M) Equipment and others a. Necessary costs to develop and publish the training materials. b. Necessary costs to hold capacity building program for trainers from NGOs.

Special remarks (Important assumptions, , project sustainability, etc)

OF 3: Review and implementation of bait fish management plan

Target Area: Whole country
Target group: All oceanic fisheries
Project period: 2018 –2020

Narrative Summary	Objectively Verifiable Indicators	Means of Verification
Overall Goal Sustainable live bait fish resource use is achieved.	• Increase ratio of population who has adequate understanding on live bait fish resource management	• MoFA annual report/ Fisheries Management Section's report
Project Purpose Framework for fisheries management of live bait fish resources is established.	• The new live bait fish management plan is enforced by end of 2020.	• Government gazette/ official announcement
Outputs 1. The "Live Bait Fishery Management Plan 2013" and other related legal framework are reviewed. 2. New integrated live bait fish management plan is drawn up. 3. The new live bait fish management plan is enforced.	• A consultation paper is submitted to MoFA by end of 2018. • The new live bait fish management plan is established by 2019. • The new live bait fish management plan is approved by the Government by 2020.	• Consultation paper • Draft of the new live bait fish management plan • MoFA annual report/ Fisheries Management Section's report

Activities

1-1 Establish the live bait fish management committee that includes all stakeholders related to the fishery
1-2 Implement technical reviewing of the management plan 2013 and related legal documents
1-3 Prepare a consultation paper for improvement of the live bait fish management

2-1 Analyze the problems and necessary actions including both fisheries and environmental issues
2-2 Draft a roadmap of actions
2-3 Draft the new integrated live bait fish management plan

3-1 Hold stakeholder consultation workshop and revise the management plan if necessary.
3-2 Get approval of the bait fish management plan by the Government

Inputs (indicate the budgets, if possible)

Maldives	Partner/donor
Personal a. MoFA Fisheries Management Section b. MRC members Equipment and others a. Arrangements of the management committee b. Involvement of fishers to the stakeholder consultation workshop	Personnel a. Fisheries Management expert b. Legal expert on Fisheries Management Equipment and others a. Necessary costs of consultation workshop

Special remarks (Important assumptions, , project sustainability, etc)

OF 4: Extension of improved live bait stocking system in pole-and-line fishery

Target Area: Whole country
Target group: Pole-and-line fishers
Project period: 2018 – 2022

Narrative Summary	Objectively Verifiable Indicators	Means of Verification
Overall Goal Live bait fishery is managed effectively.	• Waste using live bait declines. • Catch amount of live bait declines.	• Observer survey reports
Project Purpose Modified live bait tank associated with improved bait handling methods are extended among pole-and-line fishing vessels	• Modification of in-board bait tank is carried out for more than 3 boats annually after 2019.	• Monitoring report of the project
Outputs 1. Results of the pilot project of MASPLAN regarding proper management of live bait are disseminated for boat owners/investors. 2. Fishers acquire practical techniques on live bait handling and operation of improved in-board bait tank	• More than 10 awareness seminars are carried out annually. • More than 3 programs are broadcasted through the radio/TV • More than 20 fishers participate in the technical training program	• Monitoring report of the project

Activities

1-1 Prepare the materials for awareness activities such as brochures, posters and bait tank model.
1-2 Prepare the plan of awareness seminars which will be held at selected islands where the boat owners are easy to gather.
1-3 Prepare public awareness programs to be announced through the radio/TV broadcasting.
1-4 Carry out awareness seminars and programs

2-1 Prepare on-board training program about bait handling and in-board bait tank operation.
2-2 Carry out the on-board training.

Inputs

Maldives	Partner/donor
Personal a. MoFA Fisheries training, extension and promotion section b. MRC researcher(s) Equipment and others a. Necessary cost to hold awareness program and training. b. Materials for awareness program	Personnel Equipment and others

Special remarks (Important assumptions, , project sustainability, etc)

OF 5: Development of new masdhoni design

Target Area: Whole country
Target group: All oceanic fisheries
Project period: 2019 –2020

Narrative Summary	Objectively Verifiable Indicators	Means of Verification
Overall Goal The standard design of fishing vessels is mainstreamed in the country	• 50% of newly planned boats follow the new design in 2025	• MoFA licence record
Project Purpose Standard design of the 5th generation masdhooni (fishing vessel) is shared with relevant persons in the Maldives.	• New standard masdhooni design is publicised by 2020	• Annual report of MoFA
Outputs 1. Design concept of the vessel is prepared 2. Basic design of the vessel is carried out	• Approved design concept of MoFA • New standard design of fishing vessel.	• Minute of meetings of Advisory Committee • Basic design report
Activities 1-1 Establish the technical advisory committee for "5th generation masdhooni". 1-2 Discuss on the basic principle of standard design considering the safety navigation, improving fish quality, recent technical development in fishing gear, efficient fuel consumption and also advanced vessel design such as that in Japan 2-1 Preparation of the terms of reference for vessel design consultants. 2-2 Hire candidate consultants. 2-3 Evaluate and selection of a consultant. 2-4 Execution of basic design work including fish hold insulation and equipment on-board		
Inputs (indicate the budgets, if possible)		
Maldives	**Partner/donor**	
Personal a. MoFA/ MRC staff Equipment and others a. Arrangements for the technical Advisory Committee b. Necessary costs to promote the new design to public	Personnel a. Fishing technical expert b. Fishing vessel designer Equipment and others a. Cost for consultancy works	
Special remarks (Important assumptions, project sustainability, etc.)		

OF 6: Promotion of private investment

Target Area: Male
Target group: Private sector
Project period: 2023 – 2025

Narrative Summary	Objectively Verifiable Indicators	Means of Verification
Overall Goal Activities of the oceanic fisheries Sub-Sector are diversified and developed steadily	• Fishing vessels owned by local fishers for carrying out longline and deep sea fishing are increased year by year	• MoFA license record
Project Purpose Investment for new oceanic fishing activities is increasing	• Number of business plan application is increasing	• Bank records
Outputs 1. Economic feasibility of new oceanic fishing activities is clarified.	• Result of feasibility analysis	• Feasibility study report
2. Preferential investment policy is promoted.	• Agreement by MoFA on the preferential investment policy for the new fishing activities • Draft of regulation for preferential investment	• Annual report of MoFA • Draft regulation
3. Preparation and submission of individual business plans is supported.	• Number of workshop held • Number of consultation to private sector	• Template/standard of business plan • Project report

Activities

1-1 Investigate a series of cost and profit concerning the new oceanic fishing activities, i.e., vessel construction cost, operation cost, expected fish catch, expected sales price, expected profit, etc.
1-2 Analyze the economic feasibility.
2-1 Formulate an advisory committee on the preferential investment policy.
2-2 Deliberate the policy in the committee.
2-3 Hold stakeholder consultation with candidate investors including private companies.
2-4 Incorporate the policy of MoFA.
2-5 Lobby for establishment of supportive legislation

3-1 Draft the template/standard of "the business plan".
3-2 Hold workshop about how to prepare the business plan.
3-3 Give consultation to private sector about how to submit business plan application to financing organizations.

Inputs (indicate the budgets, if possible)

Maldives	Partner/donor
Personal a. MoFA Fisheries Training, Extension and Promotion Section b. MoFA legal staff Equipment and others a. Arrangements for stakeholder consultation b. Necessary costs for promotion functions c. Subsidy budgets to hire management consultants	Personnel a. Fisheries legal expert b. Fisheries business plan consultant/ lecturer to local consultant Equipment and others a. Publication of the template/standard of "the business plan"

Special remarks (Important assumptions, , project sustainability, etc)

OF 7: Development of new deep sea fisheries (Diamond back squid and other fishes)

Target Area: Whole country
Target group: MoFA/MRC
Project period: 2016 Oct – 2022

Narrative Summary	Objectively Verifiable Indicators	Means of Verification
Overall Goal Diamond back squid (DBS) and other deep sea fisheries become fisheries in the Maldives.	• Number of licensed deep-sea fishing vessels and/or total catch amount of the target species.	• MoFA licence list / statistic book
Project Purpose Potential new deep sea fisheries are established, i.e., DBS and/or other deep-sea fisheries.	• Deep sea fishing vessel of private sector start operation by 2022.	• Progress report of MASPLAN • Research paper
Outputs 1. Availability of untapped deep-sea resources is demonstrated by MASPLAN preliminary resource survey and its continual survey. 2. Feasibility study for new deep sea fisheries is examined. 3. Fisheries management framework is established. 4. The new fisheries with recommended fishing gears and methods are extended to local fishers.	• Untapped new deep sea fisheries resources are found by March 2017 for MASPLAN survey. • Resources level and distributions are estimated by 2020. • The feasibility study report is made by end of 2019. • New regulations rerated to TAC, Individual Quota (IQ) and licensing for the new deep sea fisheries are enforced by 2020. • First license for the new deep sea fisheries is issued by 2022.	• Report of the MASPLAN resource survey • Feasibility study report • Government gazettes or official announcement • MoFA licence list

Activities

1-1 Obtain basic information for planning of the untapped deep-sea fishery resource survey.
1-2 Plan and prepare the necessary fishing gears and equipment for the resource survey.
1-3 Implement the resource survey on the distribution states of unutilized deep-sea fishery resources.

2-1 Carry out market researches on demand and prices etc. on local and international markets.
2-2 Analyze feasibility depending on the potential catch quota and number of operating fishing boats.
2-3 Consolidate the results into the feasibility study report.

3-1. Decide TAC for the target species
3-2. Decide maximum number of licenses allowed
3-3. Decide IQ for each license
3-3. Establish a national regulation for the new deep sea fisheries.

4-1. Plan awareness and training program for new deep sea fishing method
4-2. Hold awareness program for fishers on these new fisheries.
4-3. Implement training on fishing techniques and resource management targeted to interested fishers
4-4. Support procurement and preparation of fishing gears and equipment
4-5. Issue a license to fishers (who meet the required conditions such as attendance to the training and preparation of the necessary gears and equipment)

Inputs (indicate the budgets, if possible)	
Maldives	**Partner/donor**
Personal a. MRC researcher(s) b. MoFA official from Fisheries Training, Extension and Promotion Section c. Feasibility study researcher Equipment and others a. A part of operating costs of research vessel for preliminary resources survey b. Necessary costs to carry out feasibility study, awareness and training programs.	Personnel a. Fishing technical expert (3 M/M) b. Fisheries resources management expert (2 M/M) Equipment and others a. Running costs of preliminary resource survey b. Fishing gears and equipment for preliminary resource survey
Special remarks (Important assumptions, , project sustainability, etc) 1) "Output 1" is carried out as a pilot project of MASPLAN. 2) The experimental boat for the pilot project (Output 1) is provided by MoFA.	

OF 8: Establishment of fisher's marinas

Target Area: Whole country
Target group: All oceanic and reef fisheries
Project period: 2015 –2018

Narrative Summary	Objectively Verifiable Indicators	Means of Verification
Overall Goal Fish quality and exports are increased with efficient fishing operation based on improving environment of basic services for fishers.	• Interview survey and policy evaluation	• MoFA annual report/ policy evaluation report
Project Purpose Improving environment of basic services for fishers, for rest, recreation, training and information sharing.	• 80% of fishers use the facility and services by end of 2019.	• MoFA annual report/ marina construction report
Outputs 1. The marinas in 4 regions of the country are established. 2. The system of soft-services that includes fisheries information and training materials is established in the marinas.	• The 4 marinas are established by 2018. • The soft-services system is established by 2018.	• MoFA annual report

Activities

1-1 Hold the public hearing meetings in the 4 proposed sites.
1-2 Draw the plan of each 4 marinas reflecting fishers' opinions in the public hearings.
1-3 Construct the marinas in all 4 proposed sites.

2-1 Define the information and training content to be supplied to fishers.
2-2 Prepare information material such as internet services, brochures, video program etc.
2-2 Prepare training programs.

Inputs (indicate the budgets, if possible)

Maldives	Partner/donor
Personal a. MoFA Fisheries Infrastructure Development Section b. MoFA Fisheries Management Section/ Training Section Equipment and others a. Arrangements for the public hearing b. Involvement of fisheries private sector/ atoll councils	Personnel Equipment and others a. Necessary costs to construct the marinas b. Necessary costs to develop the information materials and training programs

Special remarks (Important assumptions, , project sustainability, etc)

RF 1: Improvement of biological, socio-economic and statistical data collection and analysis systems

Target Area: Whole country
Target group: Whole Reef Fisheries Sub-Sector
Project period: 2016 – end 2025

Narrative Summary	Objectively Verifiable Indicators	Means of Verification
Overall Goal Reef fisheries are managed sustainably, in particular thanks to a proper data collection and analysis system	• All stocks of reef fish show good indications on resource status • Reef Fisheries are eco-certified	• Annual reports of MoFA and MRC • Stock assessment reports
Project Purpose Data collection and analysis systems for reef fisheries are developed / improved	• Proper data on reef fisheries is collated, analyzed and used for management purposes	• Annual reports of MoFA and MRC • Database at MRC
Outputs 1. A Frame Survey for Reef Fisheries is carried out on a regular basis 2. Field test of data monitoring and eco-labelling is carried out in North Malé Atoll (Pilot Project) 3. The data system for exported fish and sea products is improved 4. The statistical data collection project "Regenerate" is completed in one atoll then extended to other atolls 5. The biological and statistical data collection and analysis for general reef fish, grouper, sea cucumber, aquarium fish and lobster is improved and successfully implemented 6. Certification programmes for sustainable general reef fisheries, grouper, and aquarium fish (eco-labelling) are designed and implemented	• No. of fishers, fishing vessels and fish traders per type of reef fisheries and per island • No. of resorts and fishers / fish traders successfully collaborating in pilot project • Quantities and values of export commodities per types per year. • Catches per type of reef fisheries and per atoll per year • No. of certification schemes designed and implemented	• Annual Frame Survey Report • MASPLAN Progress Report 2 (results of the Pilot Project) • Regenerate reports • Annual reports of MoFA and MRC

Activities

1.1 Design the Survey methodology
1.2 Implement the Survey and produce Survey Report on a yearly basis

2.1 (see Pilot Project in separate document)

3.1 Rview and improve catch certificate, logbook system and export certificate for Reef Fish, Grouper and Aquarium Fish
3.2 Implement the revised system

4.1 Complete the Regenerate Project
4.2 Extend the Regenerate Project to other atolls

5.1 Assess the existing system for biological and statistical data collection and analysis for the various reef fisheries
5.2 Implement the identified needed improvements

6.1 Review of the eco-label scheme of the Reef Fisheries Pilot Project
6.2 Expand the eco-label scheme for Reef Fisheries to the whole country
6.3 Adjust the eco-label scheme to grouper and aquarium fish and pilot it on some atolls
6.4 Expand the eco-label scheme for grouper and aquarium fish to the whole country

Inputs

Maldives	Partner/donor
Personnel a. MRC staff b. MoFA staff	***Japan*** Personnel a. MASPLAN staff

Equipment and others a. Expenses for meetings b. Domestic travels	Equipment and others
Special remarks (Important assumptions, project sustainability, etc.) 1) The Pilot Project (Output 2) is implemented independently, using a specific budget 2) The Regenerate Project is implemented by IUCN. Its 2nd phase is presently underway	

RF 2: Improvement of relevant legislation about reef fisheries

Target Area: Whole country
Target group: Whole Reef Fisheries Sub-Sector
Project period: 2016 – end 2025

Narrative Summary	Objectively Verifiable Indicators	Means of Verification
Overall Goal Fisheries Sector has an updated and complete legal framework for proper Resource Management	• The Reef Fisheries Sub-Sector is managed according to a complete legal framework	• Legalized documents
Project Purpose A complete set of updated laws and regulations about reef fisheries is available	• All legal documents are approved at government level	• Legalized documents
Outputs 1. The Fisheries Act is revised and legalised 2. Regulations for Reef Fisheries, Grouper, Aquarium Fish, Sea Cucumber, Lobster and Sharks are revised or designed, legalised and implemented	• Legalised Fisheries Act • Legalised Regulations on Reef Fisheries, Grouper, Aquarium Fish, Sea Cucumber, Lobster and Sharks	• Annual reports MoFA

Activities

1.1 Finalization of the Draft Revised Fisheries Act
1.2 Legalization of the Revised Fisheries Act

2.1 Design of Regulations for Reef Fisheries, legalisation and implementation thereof
2.2 Review of the Regulations for Grouper, legalisation and implementation thereof
2.3 Review of the Regulations for Aquarium Fish, legalisation and implementation thereof
2.4 Design of Regulations for Sea Cucumber, legalisation and implementation thereof
2.5 Design of Regulations for Lobster, legalization and implementation thereof
2.6 Review of the Regulations for Sharks, legalisation and implementation thereof

Inputs

Maldives	Partner/donor
Personnel a. MRC staff b. MoFA staff	• Finalization of the Fisheries Bill is underway, after initial support from FAO technical cooperation

Special remarks (Important assumptions, project sustainability etc.)

1) Review and design of Regulations is based on the results of Project 1.
2) The Regulations for each type of Reef Fishery are an integral part of the respective Management Plans, to be designed (see Project 2).

RF 3: Enhancement of fisheries compliance / enforcement

Target Area: Whole country
Target group: Whole Reef Fisheries Sub-Sector
Project period: 2017 – end 2025

Narrative Summary	Objectively Verifiable Indicators	Means of Verification
Overall Goal Law enforcement in reef fisheries Sub-Sector is properly carried out	• The Reef Fisheries Sub-Sector is managed with a reliable and complete MCS system	• MoFA license and MCS database
Project Purpose The reef fisheries Sub-Sector has the necessary requirements to ensure proper fishing enforcement	• All reef fishing vessels are equipped with GMS system and comply with e.g. licensing regulations	• MoFA license and MCS database
Outputs 1. Cooperation between Marine Police, MoFA and EPA is strengthened 2. A licensing system for all reef fishing vessels is designed, implemented and functional 3. A GSM tracking system for reef fishing vessels is implemented and functional	• No. of enforcement actions carried out, processed and finalised • No. of reef fishing vessels licensed • No. of GSM tracking system devices installed and functional	• Minutes of meetings • Enforcement processes • Annual reports MoFA

Activities

1.1 Carry out regular working sessions between Marine Police, MoFA and EPA
1.2 Prepare collaboration guideline for practical enforcement activities
1.3 Implement practical training on the enforcement

2.1 Design the licensing data base for reef fishing vessels
2.2 Deliver annual fishing licenses to all reef fishing vessels
2.3 Produce annual data on licensed boats

3.1 Define proper procedures for all reef fishing vessels are equipped with GSM, through consultation of involved stakeholders
3.2 Ensure actual implementation and functioning of GSM system by all reef fishing vessels
3.3 Monitor proper use of the GSM by the reef fishing vessels

Inputs

Maldives	Partner/donor
Personnel a. MoFA staff Equipment and others a. GSM equipment for headquarters b. GSM equipment on board fishing vessels (financed by boat owners)	

Special remarks (Important assumptions, project sustainability etc.)

RF 4: Design and implementation of reef fisheries management plans

Target Area: Whole country
Target group: Whole Reef Fisheries Sub-Sector
Project period: 2016 – end 2025

Narrative Summary	Objectively Verifiable Indicators	Means of Verification
Overall Goal The Reef Fisheries are properly managed under Management Plans which are reviewed and adjusted periodically, both at central and local (atoll) levels	• The Reef Fisheries Sub-Sector abides by the FAO Code of Conduct for Responsible Fishing and is managed with the proper needed management tools	
Project Purpose Management Plans are designed and implemented for each of the Reef Fishery, and adjusted periodically	• All Management Plans are legalized and implemented	• Legalized Management Plans
Outputs 1. The Grouper Management Plan is successfully implemented 2. The Reef Fisheries Management Plan is successfully implemented 3. The Aquarium Fish Management Plan is successfully implemented 4. The Lobster Management Plan is successfully implemented 5. The National Plan of Actions for Sharks is reviewed and possibly, a Shark Management Plan is designed and implemented 6.	• Total annual catches vs. MSYs, for each fishery	• Annual reports MoFA • Annual reports MRC
Activities 1.1 Set up the regulatory body (Committee) and make sure it is functional 1.2 Implement a reliable licencing system for all operators 1.3 Ensure that protected spawning areas are properly enforced 1.4 Review the Grouper Management Plan at regular intervals and modify it if needed 2 to 5 (same as 1.1, 1.2 and 1.4)		

Inputs	
Maldives	**Partner/donor**
Personnel a. MRC staff b. MoFA staff c. Atoll council staff Equipment and others a. Expenses for meetings b. Domestic travels	

Special remarks (Important assumptions, project sustainability etc.)
The development of resorts does not hamper drastically the fisheries activities
The atoll level is duly integrated in the process

RF5: Capacity enhancement on fishery resource management

Target Area: Whole country
Target group: All stakeholders of Reef Fisheries Sub-Sector
Project period: 2018 – end 2025

Narrative Summary	Objectively Verifiable Indicators	Means of Verification
Overall Goal Reef fisheries are implemented under proper resources and environment management	• Reef fish resource and marine environment are sound for present and future generations	• Annual reports MoFA, MRC and EPA
Project Purpose Stakeholders develop their skills on marine resource and environmental management	• The stakeholders are aware of proper resources and environment management	• Annual reports MoFA, MRC and EPA
Outputs 1. Awareness and training materials are prepared and produced 2. Awareness and training sessions are carried out	• No. of awareness materials prepared • No. of awareness and training sessions carried out • No. of stakeholders trained (fisher, fish traders, resort staff, institution staff)	• Training materials • Training reports • Annual reports MoFA
Activities 1.1 Prepare awareness and training materials on various relevant topics (e.g. on fisheries law, regulations and enforcement, Resource management, participatory atoll-based management plan, environment conservation etc.) 2.1 Carry out awareness and training sessions		

Inputs	
Maldives	**Partner/donor**
Personnel a. MoFA, MRC and EPA staff b. Atoll council staff Equipment and others a. Expenses for the trainings b. Preparation of training materials	

Special remarks (Important assumptions, project sustainability etc.)

RF6: Improvement of boat design and equipment for reef fishery

Target Area: Whole country
Target group: All grouper and reef fish fishers
Project period: 2021 – end 2023

Narrative Summary	Objectively Verifiable Indicators	Means of Verification
Overall Goal The average income of reef fishers and traders is increased	• Average income of reef fishers and traders is assessed through a survey and shows increase	• Annual reports MoFA • Survey on Fishers and Traders Income
Project Purpose The boat design and equipment are improved to ensure better use of live fish and better fish quality	• Mortality of fresh fish on board is reduced and overall quality of fish is improved	• Annual reports MoFA
Outputs 1. Possible improvements on boat design / equipment for fish handling, in particular live grouper, and ice / fish storage are identified 2. The improvements are implemented on a pilot basis 3. The improvements are disseminated to the whole country	• No. of boats with improved boat design / equipment. • Reduction of ratio on live fish mortality.	• Pilot project report • Annual reports MoFA • Improved boat / equipment

Activities

1.1 Specify current problems of boat design concerning fish handling and ice/fish storage
1.2 Examine alternative measures to improve the boat design / equipment
1.3 Propose an improved new design of fishing vessels with estimated construction cost

2.1 Identify live grouper and reef fishing vessels to be modified / supplied with improved equipment
2.2 Modify the boats and supply improved equipment
2.3 Carry out experimentation and assess results
2.4 Review increase of income of fishers and traders through survey
2.5 Design improvement scheme for expansion to other boats

3.1 Identify atolls / islands and respective fishing vessels possibly interested in the improvement scheme
3.2 Implement the improvement scheme

Inputs

Maldives	Partner/donor
Personnel a. MoFA staff Equipment and others a. Domestic travels b. Equipment for experimental modification of boats	

Special remarks (Important assumptions, project sustainability etc.)
This project is carried out in coordination with Project RF5 above

RF7: Awareness on fishing and fish handling techniques in reef fishery

Target Area: Whole country
Target group: All fishers, fish traders and resort staff linked to the Reef Fisheries Sub-Sector
Project period: 2018 – end 2025

Narrative Summary	Objectively Verifiable Indicators	Means of Verification
Overall Goal Adequate fishing and fish handling techniques are observed by the concerned actors of the reef fisheries Sub-Sector	• Fishing and fish trading are carried out in a responsible way (e.g. no undersized and protected species etc.), products are of good quality.	• Spot surveys on fishing and fish trading
Project Purpose Stakeholders develop their skills on best fishing and fish handling techniques and practices	• The concerned actors of the reef fisheries Sub-Sector implement adequate and viable techniques	• Annual reports MoFA and MFA
Outputs 1. Possible improved fishing and fish handling techniques to be introduced are identified 2. Awareness and training sessions are carried out	• No. of awareness materials prepared • No. of awareness and training sessions carried out • No. of fishers, fish traders and resort staff trained	• Training materials • Training reports • Annual reports MoFA
Activities 1.1 Analyze current technical issues regarding fishing and fish handling techniques in reef fisheries 1.2 Examine possible improved measures to solve the above issues 2.1 Prepare awareness and training materials about improved fishing and fish handling techniques 2.2 Carry out awareness and training sessions at atoll level		

Inputs	
Maldives	**Partner/donor**
Personnel a. MoFA and Maldives Fishermen's Association staff Equipment and others a. Expenses for the trainings b. Preparation and production of training materials	

Special remarks (Important assumptions, project sustainability etc.)
This Project is closely linked to Projects RF5 and RF6, as well as PP4.

AQ 1: Establishment of multi-species hatchery

Target Area: Whole country
Target group: Aquaculture farm
Project period: 2019 – 2022

Narrative Summary	Objectively Verifiable Indicators	Means of Verification
Overall Goal The Multi-species hatchery functions as the core facility of aquaculture extension	• More than 1 million juveniles of groupers and sea cucumbers are produced by 2027 • Juveniles are distributed among small- scale aquaculture farms	• Annual report of MoFA
Project Purpose Multi-species hatchery is established and operated properly	• More than 5,000 grouper juveniles and the same number of sea cucumber are produced by 2022	• Report of WB
Outputs 1. Construction plan and schedule of public-private multi-species hatchery are prepared. 2. The facilities are constructed according to the schedule based on the established 3. Juveniles of groupers and sea cucumbers are produced experimentally	• MoFA and selected private company agreed with establishment of the multi-species hatchery • Results of EIA is approved by MEE • Construction is done adequately • Planned number of staff are allocated for seed production work	• JV contract document • Architectural drawings • EIA report • Completion report of facility construction • Activity report of the hatchery

Activities

1.1 Select a private company to operate the hatchery
1.2 Exchange contact with the private company selected
1.3 Confirm basic design of the facilities

2.1 Carry out EIA of the plan
2.2 Construct the facilities
2.3 Procurement of necessary equipment such as net cage, tanks, and laboratory feed, etc.

3.1 Procurement of the broodstock and the feed
3.2 Provide technical training for the staff in Multi-species hatchery
3.3 Carry out experimental seed production of groupers and sea cucumbers
3.4 Refine seed production techniques through continuation of activities

Inputs

Maldives	Partner/donor
Personal a. Technical coordinator b. Other technical staff as per necessity	Planned investment amount will be included in the WB project.

Special remarks (Important assumptions, project sustainability, etc.)
EIA is required for facilities construction.

AQ 2: Establishment of milkfish seed production facilities to provide baits

Target Area: Southern part of the country
Target group: Pole-and-line fishers
Project period: 2018 – 2020

Narrative Summary	Objectively Verifiable Indicators	Means of Verification
Overall Goal The milkfish juveniles produced in the facility are utilized by the pole-and-line fishers	• More than 10 vessels of pole-and-line fisheries utilize the milkfish juveniles for live bait by 2027	• Annual report of MoFA
Project Purpose The milkfish juveniles as an alternative live bait are produced stably in the new facility	• More than 100t/year of milkfish juveniles is produced by 2020	• Report of MRC
Outputs 1. The facilities and materials of the producing milkfish juveniles are equipped	• The hatchery and nursing facilities of milkfish juveniles are constructed • The materials are introduced	• Completion report of facility construction
2. The appropriate technologies to produce the milkfish juveniles are prepared	• Procedure manual of milkfish juveniles production is submitted	• Technical report of the project
3. The milkfish juveniles are produced experimentally	• A series of juveniles production are operated properly	• Activity report of the hatchery

Activities

1.1 Prepare a plan of operation for the construction of the facilities
1.2 Select the appropriate construction site
1.3 Obtain the approval of the EIA by MEE
1.4 Contract a selected construction company
1.5 Construct the facilities (e.g. office, hatchery, live feed, nursing etc.)
1.6 Introduce the necessary materials (e.g. tank, pump, filter system, water system etc.)

2.1 Review the techniques of milkfish culture
2.2 Dispatch the staff to the technical training of milkfish seed production in SEAFDEC
2.3 Receive the on-site guidance by an expert of the milkfish culture including the seed production
2.4 Summarize the procedure of the production method

3.1 Procure the equipment (e.g. broodstock, formula feed etc.)
3.2 Prepare the initial feed for the larva
3.2 Carry out the experimental propagation of the milkfish
3.3 Carry out the experimental nursing
3.4 Improve the techniques and materials for the mass production

Inputs

Maldives	Partner/donor
Personal a. Project manager b. Technical staff as necessary Equipment and others a. Expense for the operation of the seed production	Personal a. Expert of milkfish culture including the propagation

Special remarks (Important assumptions, project sustainability, etc.)
EIA is required for facilities construction
Monitoring survey of the water pollution should be conducted and recorded

AQ 3: Development of domestic fish feed using by-product of fish processing

Target Area: Whole country
Target group: Aquaculture farms
Project period: 2019 - 2022

Narrative Summary	Objectively Verifiable Indicators	Means of Verification
Overall Goal Aquaculture farm utilizes the result by-product as the fish feed for aquaculture	• At least one farm utilizes processed by-product for the fish feed	• Interview survey
Project Purpose The method to utilize the by-product of fish processing for aquaculture is developed	• The workshop of the utilizing by-product for fish feed is held	• Project report
Outputs 1. Analyze the raw materials available for the fish feed in Maldives are summarized	• Information of the by-products including fish processing factory, the amount, the price, and the nutrition is collected d by 2020	• Study report
2. Comparative study on growth performance using the by-products is carried out	• The study plan is prepared by 2020 • The monitoring data is recorded during the study	• Study report
3. The method and the cost-benefit to utilize the by-products are clarified	• The manual of the utilization of the by-product is submitted by 2022	• Study report

Activities

1.1 Collect information of by-products in fish processing factories in Maldives
1.2 Summary the information of the by-products available for the fish feed
1.3 Select a by-product and fish species available for the study
1.4 Analyze the nutritional composition of the by-products

2.1 Prepare the plan of the comparative study using the by-products
2.2 Procurement of the materials for the study
2.3 Carry out the comparative study between the processed by-product and formula feed
2.4 Record the necessary data through the monitoring

3.1 Summary the method to process the by-products
3.2 Clarify the effect of the by-products for the aquaculture

Inputs

Maldives	Partner/donor
Personal a. Staff of MoFA b. Staff of MTDF/MRC Equipment and others a. Processing equipment b. Measuring equipment for nutrition analysis c. Materials of the study	

Special remarks (Important assumptions, project sustainability, etc.)

AQ 4: Refinement of existing aquaculture techniques

Target Area: Multi-species hatchery and MTDF/MRC
Target group: MRC experts and private technicians
Project period: 2020 – 2023

Narrative Summary	Objectively Verifiable Indicators	Means of Verification
Overall Goal The appropriate techniques are developed continually in Multi-species hatchery and MTDF/MRC	• Four reports of improvement of aquaculture techniques are reported by Multi-species hatchery and MTDF/MRC in every year	• Annual report of MoFA
Project Purpose The existing techniques of seed production and aquaculture is refined to suit Maldives environment.	• The techniques are summarized in the technical report	• Annual report of MRC
Outputs 1. The plans of the verification experiments both the seed production and grow-out are prepared	• The plan of the experiment is prepared by 2021	• Project report
2. The planned experiments are carried out at Multi-species hatchery and MTDF/MRC	• The monitoring data is recorded during the experiment	• Project report
3. The results of the experiment are summarized in the report	• The report of the experiment is submitted by 2022	• Project report

Activities

1.1 Investigate existing seed production and grow-out techniques in the world, regarding priority aquaculture species such as sandfish and groupers.
1.2 Summarize the necessary techniques to promote aquaculture in Maldives
1.3 Select the potential technique for the experiments
1.4 Prepare plans of operation for the experiments

1.1 Procurement the necessary equipment
1.2 Set up the experiments
1.3 Carry out preliminary experiment
1.4 Review the design of the experiment based on the preliminary experiment
1.5 Carry out the experiment including the monitoring

3.1 Collect the data of the experiment at the termination
3.2 Analyze the data and evaluate the results
3.3 Prepare the report of the appropriate techniques

Inputs

Maldives	Partner/donor
Personal a. 2 staff members of MRC b. 4 staff members of MTDF/MRC Equipment and others a. Expense of the experiment	Personal a. Expert of seed production b. Expert of grow-out Equipment and others a. Expense for the equipment

Special remarks (Important assumptions, project sustainability, etc.)
Impact on the environment, e.g. due to organic matter rom feed remains should be assessed in the report.

AQ 5: Training and demonstration capacity building of MTDF/MRC

Target Area: MTDF/MRC
Target group: Staff of MTDF/MRC and MRC
Project period: 2018 – 2020

Narrative Summary	Objectively Verifiable Indicators	Means of Verification
Overall Goal Mariculture extension system by MTDF/MRC is enhanced in Maldives	• The technical training and on-site training by MTDF/MRC are organized annually by 2024	• Annual report of MoFA
Project Purpose The capacity of MTDF/MRC regarding training, demonstration and research is improved.	• More than 80% of trainees participated in the training at MTDF/MRC gives good evaluation	• Report of MTDF
Outputs 1. Current facilities and equipment are improved to meet the demand for training, demonstration and research.	• Facilities and equipment installed.	• Observation of site
2. The staff members of MTDF/MRC acquire appropriate knowledge and techniques	• Training program that MTDF/MRC staff participated	• Report of MTDF/MRC
3. The teaching materials of the technical training held in MTDF/MRC are prepared	• Training manuals on seed production and grow-out are prepared by 2020	• Training manuals prepared
4. Technical training and on-site guidance organized by the staff of MTDF/MRC is carried out	• Number of training sessions for private sectors • Number of demonstration sessions	• Annual report of MRC • Report of MTDF/MRC

Activities

1.1 Refine on-going renovation and reconstruction plan of MTDF/MRC
1.2 Construct facilities based on the plan
1.3 Procure equipment based on the plan

2.1 Make a plan of study trip and technical training
2.2 Organize the study trip to developed country of mariculture
2.3 Participate in the technical training in the organization such as SEFDEC to improve the weakness
2.4 Share the learnt techniques among the staff of MTDF/MRC

3.1 Summarize the techniques developed in MTDF/MRC and knowledge learnt in the study trip and the training
3.2 Make the plan of the aquaculture extension
3.3 Prepare the both manuals seed production and grow-out

4.1 Make a plan of technical training at MTDF/MRC
4.2 Procurement of materials for the training
4.3 Carry out the technical training at MTDF/MRC
4.4 Follow up the techniques in private farms through on-site guidance
4.5 Introduce the results of on-site guidance in the manuals

Inputs	
Maldives	**Partner/donor (WB)**

Personal a. 2 staff members of MRC b. All staff members of MTDF/MRC Equipment and others a. Expense of print out the manuals b. Transportation for the on-site guidance	Equipment and others a. Expense of study trip (e.g. Thailand) b. Expense of technical training (e.g. SEAFDEC in Philippine) c. Expense of the technical training
Special remarks (Important assumptions, project sustainability, etc.)	

AQ 6: Extension of potential mariculture techniques

Target Area: Whole country and MTDF/MRC
Target group: Aquaculture farms and potential farms
Project period: 2018 – 2022

Narrative Summary	Objectively Verifiable Indicators	Means of Verification
Overall Goal Number of aquaculture farms is increased in Maldives	• More than 2 private farms launch to operate the mariculture every year	• Annual report of MoFA
Project Purpose Adequate mariculture techniques are extended to private sector	• More than 10 private farms apply the developed aquaculture techniques	• Monitoring survey report of the project
Outputs 1. Seed production techniques of grouper and sea cucumber is refined	• Manuals of seed production for more than 2 species are prepared by 2019	• Manuals prepared
2. Economically sound grow-out culture techniques of grouper and sea cucumber are available	• Manuals of grow-out culture for more than 2 species is prepared by 2019	• Manuals prepared
3. Adequate feed using locally available materials is developed	• Combined feed using locally available material is produced by 2020	• Technical report of the project
4. The above technical information is disseminated for private sectors	• Technical training is carried out at MTDF/MRC, 2 times a year • Technical seminar/workshop is held, 2 times a year	• Training records of the project

Activities

1.1 Prepare seed production manual of grouper based on the experiences at MTDF/MRC and Multi-species hatchery
1.2 Prepare seed production manual of sea cucumber based on the experiences at MTDF/MRC and Multi-species hatchery as well as advanced private farm

2.1 Prepare grow-out culture manual of grouper based on the results of feasibility study
2.2 Prepare grow-out culture manual of sea cucumber based on the results of feasibility study

3.1 Investigate the availability of local materials such as fish meal
3.2 Experimentally produce combined feed using the above materials
3.3 Carry out rearing experiments using the above feed

4.1 Prepare training programs at MTDF/MRC
4.2 Conduct the training at MTDF/MRC
4.3 Prepare seminar/workshop materials
4.4 Hold seminar/workshop in various sites of the country
4.5 Carry out monitoring survey about the effects of technical dissemination

Inputs

Maldives	Partner/donor
Personal a. MRC researcher(s) b. Technicians who carry out feed experiments at MTDF/MRC Equipment and others a. Print out the manuals	Personnel a. Feed specialist Equipment and others a. Equipment necessary for carrying out experimental feed preparation and rearing b. Imported formula feed as control

Special remarks (Important assumptions, project sustainability, etc.)
Technical assistance of donor is expected

AQ 7: Promotion of aquaculture through formal education system

Target Area: Whole country
Target group: School teachers and children
Project period: 2023 – 2025

Narrative Summary	Objectively Verifiable Indicators	Means of Verification
Overall Goal Basic knowledge of Maldivians on aquaculture is improved	• Most of the people understand the necessity and importance of aquaculture	• Annual reports of MoFA and Ministry of Education
Project Purpose Aquaculture is taught regularly in the course of formal education system	• Aquaculture module is shown in the annual timetable of school curriculum	• School curriculum
Outputs 1. Teaching materials on aquaculture are prepared	• Text book and pamphlet of aquaculture are prepared by 2024	• Text book and manual prepared
2. Aquaculture modules are incorporated into the existing curriculum	• Lectures on aquaculture are carried out at more than 3 schools • More than 3 field visits are implemented	• Project activity report
3. Effectiveness of the educational and awareness program is evaluated	• Relevant persons evaluate the aquaculture modules effective • Improved teaching program is prepared	• Evaluation report

Activities

1.1 Examine teaching and awareness materials on aquaculture
1.2 Prepare aquaculture modules in terms of text book and pamphlet

2.2 Organize lectures and seminars from local and visiting experts in line with the modules prepared
2.3 Organize field visits to aquaculture farm
2.4 Organize internship program at aquaculture farms and research facilities

3.1 Review the educational and aware activities of the projects
3.2 Carry out questionnaire survey on the effectiveness of those activities for the lectures and students
3.3 Make evaluation report of the modules
3.4 Improve the teaching program

Inputs

Maldives	Partner/donor
Personal a. 2 staff members of MoFA b. 1 staff member of Ministry of Education c. Local consultant for the evaluation of the aquaculture modules Expense a. Print out the teaching materials b. Travels to prepare filed visit and site of internship	Ministry of Education, Maldives shall be a partner.

Special remarks (Important assumptions, project sustainability, etc.)

AQ 8: Improvement of aquatic animal health management

Target Area: Whole country — Project period: 2019 – 2020
Target group: Aquaculture farm — (Continuation)

Narrative Summary	Objectively Verifiable Indicators	Means of Verification
Overall Goal Fish trade is carried out under improved biosecurity system	• Quarantine certificates are issued routinely for all aquatic animals	• Annual report of MoFA
Project Purpose Biosecurity system is formulated for aquatic animals particularly for aquaculture species	• Quarantine certificates are issued for aquaculture species. • More than 20 diagnostic certificates are issued for aquaculture farms.	• Annual report of MoFA
Outputs 1. Relevant biosecurity facilities are established for aquatic animals	• An aquatic animal quarantine facility is completed by 2019 • An analytical laboratory of fish disease is established	• Report of MoFA
2. Quarantine service is started at custom office	• At least one pathologist is allocated at the quarantine office. • Quarantine certificates are started issuance	• Report of custom office
3. Aquatic disease diagnostic service is available	• At least one pathologist is allocated at the fish disease laboratory • Diagnostic test is started	• Report from the laboratory
4. Private aquaculture farms can access easily to healthy broodstock and seeds.	• Live fish trade is carried out based on the regulation	• Report of custom office

Activities

1.1 Prepare the plan of new facility for quarantine control in Hulhumalé
1.2 Prepare the plan of new laboratory on fish disease
1.3 Construct the facilities
1.4 Install the equipment for laboratory analysis

2.1 Train or recruit the expert on quarantine check of aquatic animals
2.2 Allocate them for the quarantine facility
2.3 Clarify the inspection rule of fish specimen at import and export as well as fish farms

3.1 Train or recruit the expert on fish health management
3.2 Allocate them for the diagnostic service
3.3 Implement the diagnostic service for fish farms

4.1 Establish the system on issuance of fish health certificates for broodstock and seeds
4.2 Hold seminar for private aquaculture farms on the biosecurity rules and regulation
4.3 Promote information services about availability of healthy broodstock and seeds

Inputs

Maldives	Partner/donor
Personal a. A pathologist and 2 staff members for quarantine Equipment and others a. Expense of operation cost for the quarantine	Personnel a. Fish pathologist Equipment and others a. Facility and equipment for the quarantine b. Expense 1. Technical training for the quarantine staff 2. Preliminary examination 3. Survey of the fisheries marketing

Special remarks (Important assumptions, project sustainability, etc.)
Relevant regulations about the trade of living aquatic animal shall be reviewed.

AQ 9: Strengthening institutional mechanism on aquaculture activities

Target Area: Whole country
Target group: Aquaculture farm
Project period: 2022– 2025

Narrative Summary	Objectively Verifiable Indicators	Means of Verification
Overall Goal The certification system is applied for private aquaculture farms	• More than 2 private aquaculture farms obtain the certification	• Annual report of MoFA
Project Purpose An appropriate institutional mechanism on aquaculture starts working in Maldives	• Guidelines and certification system is officially accepted by MoFA by 2025	• Annual report of MoFA
Outputs 2. The information related to the aquaculture management and institutional framework is reviewed	• List of necessary documents such as guidelines and regulations is prepared	• Progress report
3. Guidelines of the government about monitoring and inspection of aquaculture are prepared.	• Draft guidelines about monitoring and inspection are submitted by 2023.	• Relevant guidelines prepared
4. An aquaculture certification system suitable for the Maldives is prepared	• An aquaculture certification system is drafted and submitted by 2023	• Certification system prepared

Activities

1.1 Investigate examples of aquaculture management and institutional systems in the world
1.2 Carry out the interview survey to aquaculture farms in Maldives regarding necessity and adequate contents of the relevant guidelines and regulations
1.3 Prepare a lineup of required guidelines and regulations

2.1 Make draft guidelines about monitoring and inspection system for the government
2.2 Organize stakeholder workshop about the guidelines
2.3 Revise and improve the guidelines
2.4 Encourage official approval of the guidelines

3.1 Examine the contents of the certification system
3.2 Organize stakeholder workshop about the system
3.3 Prepare the draft of aquaculture certification system
3.4 Encourage official approval of the certification system

Inputs

Maldives	Partner/donor
Personal a. 2 staff members of MRC b. 1 staff member of MoFA Equipment and others a. Expense of the survey to aquaculture farm b. Expense of the discussion	

Special remarks (Important assumptions, project sustainability, etc.)
Environmental aspects shall be dealt with in the guideline.

AQ 10: Development of financing system for aquaculture

Target Area: Whole country
Target group: Aquaculture farms
Project period: 2020 – 2023

Narrative Summary	Objectively Verifiable Indicators	Means of Verification
Overall Goal Aquaculture Sub-Sector can obtain finance efficiently based on the market mechanism	• More than 50% of private farms for entering aquaculture industry uses the platform	Monitoring survey
Project Purpose Adequate investment platform of aquaculture for investors and local private sectors is established	At least 2 aquaculture farms are benefited by the investment plate form	Information from beneficiaries
Outputs 1. Current banking policies for assisting new enterprise development is investigated 2. The policy and plan of relevant Ministries regarding taxation and subsidization in relation to aquaculture activities are investigated 3. An invest platform that would enable foreign investors to connect with local private sectors for aquaculture is established	Financial feasibility report is prepared by 2021 Baseline survey report on the taxation and subsidization is prepared by 2021 The investment platform for foreign investors and local private sector is functioning	Report of the project Report of the project Web site of MoFA

Activities

1.1 Review the current situation of financing in Maldives
1.2 Conduct interviews on the financing policy of banks
1.3 Prepare sample business plan of aquaculture industry for financing
1.4 Investigate the possibility of financing for the sample business plan of aquaculture

2.1 Summarize the taxation system on the aquaculture industry
2.2 Review the subsidization system available for aquaculture activities
2.3 Examine sample application form of the subsidization for aquaculture
2.4 Prepare the report on the problems and issues concerning the taxation and subsidization for aquaculture

3.1 Organize the working group for the establishment of investment platform
3.2 Examine the adequate framework of credit in Maldives
3.3 Establish the concept and regulation of the investment platform
3.4 Endorse the system of investment platform at MoFA level
3.5 Carry out awareness activities on the investment platform, e.g. through web site creation

Inputs

Maldives	Partner/donor
Personal a. 2 staff members of MoFA Equipment and others a. Local consultants for baseline survey and establishment of web site b. Expense for surveys and meetings	Financial experts/Economists

Special remarks (Important assumptions, project sustainability, etc.)
Technical assistance of donor is expected.

PV 1: Extension of improved on-board handling techniques for tuna hand-line fishery

Target Area: Whole country
Target group: Tuna hand-line fishers, Government officials and ptechnical staff of processing industry
Project period:5 years from April, 2018

Narrative Summary	Objectively Verifiable Indicators	Means of Verification
Overall Goal Fishers retain more profit from fishing.	• Income of fishers	• Impact survey
Project Purpose Fish grade caught by fishers is improved.	• Ratio of grade C and rejected in the total catch per fishing boat	• Project document
Outputs 1. Training course for improving capacity of Government officials and technical staff of the processing industry is conducted.	• Program / curriculum • Implementation plan of MoFA with budgetary allocation • Number of participants	• MoFA document • Project report
2. Awareness program on proper fish handling on board is conducted.	• Contents of awareness program • Implementation plan of MoFA with budgetary allocation • Number of the awareness program	• MoFA document • Project report
3. Training course for fishers on technical improvement is conducted.	• Program / curriculum • Implementation plan of MoFA with budgetary allocation • Number of participants • Number of participants who acquired the certificate	• MoFA document • Project report
4. Evaluation and monitoring system for the training is prepared and implemented.	• Evaluation topics for each training course • Level of attainment of the participants • Program /curriculum improved for the succeeding year based on the results of evaluation	• MoFA document • Project report
Activities 1.1 A plan for implementation of the training is prepared. 1.2 Training program and curriculum are prepared. 1.3 Lecturers are appointed. 1.4 Teaching materials are prepared. 1.5 The training course is implemented. 1.6 Evaluation is conducted. 2.1 A plan for implementation of the awareness program is prepared. 2.2 Awareness materials are prepared. 2.3 The awareness program is implemented. 3.1 A plan for implementation of the training is prepared. 3.2 Training program and curriculum are prepared. 3.3 Lecturers are appointed. 3.4 Teaching materials are prepared. 3.5 The training course is implemented. 3.6 Evaluation is conducted. 4.1 Evaluation for the training is implemented. 4.2 Level of attainment of the participants is measured. 4.3 The results of the evaluation are taken into account in the succeeding training program.		
Inputs		

Maldives	Partner/donor
Personal a. Maldivian counterparts	*Donor agency* Personnel a. chief adviser b. coordinator c. ICT expert Equipment and consumables a. Training room b. Fishing vessel for the practice c. Audio-visual equipment d. Stationaries
Special remarks (Important assumptions, project sustainability, etc.)	

PV 2: Strengthening capacity of ice making plants

Target Area: Whole country
Target group: Fishers (oceanic and reef), fish traders, resorts
Project period: 5 years from January, 2019

Narrative Summary	Objectively Verifiable Indicators	Means of Verification
Overall Goal Sufficient ice is provided to users in Maldives.	• Quantity of ice used by users	• Impact survey
Project Purpose Necessary ice plants are established and functional in Maldives.	• Location, number of ice plants and production capacity, capacity of operational body	• MoFA report
Outputs 1. Candidate sites with socio-economic and socio-environmental conditions are identified.	• Name of atolls and islands selected • Number of fishers as potential users • Fishers' willingness and affordability to buy ice	• MoFA report • Study
2. Potential management and operational body in the candidate sites is clarified.	• Status of the management and operational bodies • Management skills including O&M	• MoFA report • Study
3. Necessary ice plants with capacities are identified.	• Location, number of ice plants and production capacity, capacity of operational body (Plan)	• Study
4. Basic designs of the ice plants are completed.	• Blueprints of the Basic Designs (B/D)	• Study
5. Detailed designs of the ice plants are completed.	• Blueprints of the Detailed Designs (D/D) • Tender documents	• Study
6. Ice making plants are functional.	• Number of ice plants built, supply of ice plants	• MoFA report
7. Access to ice is improved.	• Quantity of ice used by fishers per fishing operation • Number of stakeholders who use ice for quality improvement of fish in each site	• Baseline & impact survey

Activities

1.1 The candidate sites are selected.
1.2 Basic data such as population, number of fishers, industry etc. is collected and analysed.
1.3 Field study is planned and conducted.
1.4 Q quantity of ice needed is estimated.

2.1 Potential management and operational bodies are surveyed.

3.1 The capacity and other specifications of each ice plant are planned.

4.1 The study on the basic designs are prepared and implemented.

5.1 The study on the detailed designs are prepared and implemented.
5.2 The result of the detailed designs are compiled and reflected in the tender documents.
5.3 The contractors are selected.
5.4 The construction works are conducted.

6.1 Training on management and O&M is carried out. 7.1 Technical training on proper use of ice is carried out. 7.2 Awareness on how to use ice adequately is conducted.

Inputs	
Maldives	**Partner/donor**
Personal a. Maldivian counterparts Land Water supply Electricity	*Donor agency* Personnel a. chief b. fish quality/distribution c. capture fishery d. ice plant engineer e. environmental assessment f. ice plant management Facility, equipment and consumables, contractors Allowances for training, seminar, meeting and others
Special remarks (Important assumptions, project sustainability, etc.) Sufficient budget for travel allowance is necessary. Counterpart training (two persons per year for two years: 4 persons in total) EIA is required for facilities construction.	

PV 3: Extension of quality improvement methods for traditional processed fish

Target Area: Male, Koodoo, Gemanafushi
Target group: Small-medium processors/Cooperatives
Project period: 3 years from January, 2018

Narrative Summary	Objectively Verifiable Indicators	Means of Verification
Overall Goal Small-scale fish processors retain more profit from fish processing.	• Income of fish processors	• Impact survey
Project Purpose Modified technologies are disseminated to improve processed fish.	• Cooperatives and SMEs produce the products using the modified technologies.	• Sampling tests
Outputs 1. Fish processors obtain knowledge and technologies on improvement of traditional processed fish.	• Technologies applicable to cooperatives/SMEs are identified. • Level of attainment	• Project report
2. Fish processors utilize the knowledge and technologies to produce.	• Quantities produced per type of product	• Project report
3. Quality of Maldives Fish and Rihaakuru is improved.	• Histamine content	• Project report
4. Marketing of the products is promoted.	• Form and number of the advertisement	• Project report

Activities

1.1 Monitoring of the products sold in the market is implemented.
1.2 Monitoring of the quality of raw materials to produce Maldives Fish and Rihaakuru is implemented.

2.1 On-site guidance is conducted.
2.2 Necessary input assistance is provided.
2.3 Evaluation of the products is conducted.

3.1 Histamine content of the products is assessed.
3.2 Simple manual is prepared.

4.1 Consumers' awareness is assessed.
4.2 Food exhibition is conducted.

Inputs

Maldives	Partner/donor
Personal a. Staff of MoFA b. Sample collectors c. QC expert	*Donor agency* Personnel a. Fish processing expert Equipment and consumables a. quality analys equipment b. exhibition booth c. others

Special remarks (Important assumptions, project sustainability, etc.)

PV 4: Improvement of fish marketing system

Target Area: Whole country
Target group: Fishers, fish processors (small-scale and large)
Project period: 3 years from April, 2017

Narrative Summary	Objectively Verifiable Indicators	Means of Verification
Overall Goal Marketing of fishers and fish processors is improved.	• Number of buyers	• Baseline & end line survey
Project Purpose Distribution system of fishery products is improved.	• Quality of the products • Earnings of stakeholders	• Quality analysis report • Interview (before and after)
Outputs 1. Value chain of fishery products in Maldives is clarified. 2. Information usable for marketing is provided. 3. New pilot markets of fishery products are developed. 4. Optimum distribution system of fishery products in Maldives is proposed.	• Clarified value chain • Information provided • New pilot markets developed • Contents of the distribution system plan	• Study • MoFA report • MoFA report • MoFA report

Activities

1.1 A study is planned and implemented to clarify current distribution system of fishery products by type of commodity.
1.2 Pricing mechanism and/or system of fishery products are analysed.
1.3 Analysis of relevant stakeholders is conducted.
1.4 Laws and regulations related to fish distribution for both local and export markets are analysed.

2.1 Information usable for marketing is identified.
2.2 A system for collecting information usable for marketing is prepared.
2.3 Methodology for collecting information is designed.

3.1 Variety of end products for the pilot is determined.
3.2 Trend of end products in the local market /resort /international market is clarified.
3.3 Pilot marketing places are determined.
3.4 The result of the pilot sale is analyzed and compiled.

4.1 The results of the activities from Output 1 to Output 3 are analyzed comprehensively.
4.2 A proposal on the optimum distribution system of fishery products in the Maldives is prepared and submitted.

Inputs

Maldives	Partner/donor
Personal a. Maldivian counterparts	*Donor agency* Personnel d. chief advisor e. Coordinator f. fish marketing g. fishery information h. fishery product development Equipment and consumables e. Computers with relevant softwares. f. Mobile application equipment g. Booth for exhibition etc.

Special remarks (Important assumptions, project sustainability, etc.)

PV 5: Development of katsuobushi processing technology and facility

Target Area: Maavah
Target group: Small andmedium-scale processors
Project period: 4 years from January, 2021

Narrative Summary	Objectively Verifiable Indicators	Means of Verification
Overall Goal Small-medium-scale fish processors retain more profit from katsuobushi processing.	• Income of fish processors	• Impact survey
Project Purpose Small andmedium-scale fish processors produce katsuobushi using appropriate technology and facility.	• Number of processors of katsuobushi using the technologies and facility.	• Impact survey
Outputs 1. Fish processors obtain knowledge and technologies on the production of katsuobushi.	• Number of processors who participate in the training. • Level of attainment	• Project report
2. Appropriate facility for producing katsuobushi is designed and constructed.	• Design of the facility • Compleion of the facility	• Project report
3. The facility is used to produce katsuobushi.	• Production (quantity and quality)	• Project report
4. Marketing of the products is promoted.	• Form and number of the advertisement	• Project report
Activities 1.1 Technical training is implemented for fish processors. 1.2 Evaluation and monitoring of the training is conducted. 2.1 Basic design of the facility is prepared. 2.2 The facility is constructed. 2.3 The operational system including O&M is decided. 3.1 Process for obtaining raw materials is established. 3.2 Trials of the production are carried out. 3.3 The quality of products is assessed. 4.1 Marketing strategy is designed. 4.2 Advertisement for the products is carried out to attract buyers.		

Inputs

Maldives	Partner/donor
Personnel a. Staff of MoFA b. National contractor to build the facility	*Donor agency* Personnel a. Fish processing expert b. Marketing expert Facility a. Katsuobushi production facility Equipment and consumables a. Relevant equipment set in the facility b. Quality analys equipment c. others

Special remarks (Important assumptions, project sustainability, etc.)

PV 6: Development of the minimum national standards/regulations for fishery products

Target Area: Whole country
Target group: Fish processors, fish distributors and fish importers
Project period: 5 years from April, 2016

Narrative Summary	Objectively Verifiable Indicators	Means of Verification
Overall Goal Quality of fishery products is improved.	Compatibility with the National Standards	• Sampling test
Project Purpose Minimum national standards/regulations on fishery products for the import and local market are developed and enacted.	• Minimum national standards/regulations developed and enacted	• MoFA document
Outputs 1. The minimum national standards/regulations to be developed are identified. 2. The minimum national standards/regulations are drafted 3. The minimum national standards/regulations are enacted.	• Identified national standards/regulations • Drafts prepared • National standards/regulations enacted	MoFA document/ MOED document/ MFDA document

Activities

1.1 Existing national standards/regulations are reviewed.
1.2 National standards/regulations to be partially modified are clarified.
1.3 National standards/regulations to be developed are identified.

2.1 The existing national standards/regulations are modified and drafted.
2.2 The new minimum national standards/regulations are drafted.

3.1 The drafts of the modified minimum national standards/regulations are reviewed in MoFA steering committee.
3.2 The drafts of the new minimum standards/regulations are reviewed in MoFA steering committee.
3.3 The minimum national standards/regulations are approved by the government.
3.4 The minimum national standards/regulations enter into force.
The enacted minimum national standards/regulations are introduced to the public.

Inputs

Maldives	Partner/donor
Personal b. Maldivian counterparts	*Donor agency* Personnel a. chief advisor b. legal expert Equipment and consumables a. Seminar room b. Audio-visual equipment c. Stationaries

Special remarks (Important assumptions, project sustainability, etc.)

Hygiene regulation was enacted on October 29, 2014. It should be disseminated to the relevant Ministries such as MoED, MFDA and to fish processors after it is gazeted.

PV 7: Establishment of training system for fish quality assurance

Target Area: TH. Hirilandhoo Island & L. Maamendhoo/Gan Island
Target group: Fishers, fish processing companies, Government officials

Project period: 3 years from April, 2017

Narrative Summary	Objectively Verifiable Indicators	Means of Verification
Overall Goal Fishers and fish processing companies retain more profit from business.	• Income of fishers • Profit of fish processing companies	• Impact survey • Financial statement
Project Purpose Training system for fish quality assurance is established and operational.	• Number of training courses • Program /curriculum for each training course • Implementation plan of MoFA • Number of participants per training course	• MoFA document
Outputs 1. Training curriculum is approved and accredited.	• Program /curriculum accredited by the Maldives Qualification Authority	• MoFA document • Project report
2. Training course and curriculum for improving capacity of Government officials is conducted.	(The followings are common indicators corresponding to the Output 2, 3 and 4)	
3. Training course for upgrading capacity of technicians of fish processing companies is conducted.	• Program /curriculum • Implementation plan of MoFA with budgetary allocation • Number of participants	
4. Training course on technical improvement for fishers is conducted.	• Number of participants who acquired the certificate. • Evaluation topics for each training course	
5. Evaluation and monitoring system for the training implementation is prepared.	• Level of attainment of the participants • Program /curriculum improved for the succeeding year based on the results of evaluation	

Activities

1.1 Training program and curriculum are prepared.
1.2 The curriculum is approved by the Authority
1.3 Teaching materials are prepared.
1.4 A plan for implementation of the training is prepared.
1.5 Training program and curriculum are prepared.

2.1 Lecturers are appointed.
2.2 Teaching materials are prepared.
2.3 The training course is implemented.
2.4 Evaluation is conducted.

3.1 A plan for implementation of the training is prepared.
3.2 Training program and curriculum are prepared.
3.3 Lecturers are appointed.
3.4 Teaching materials are prepared.
3.5 The training course is implemented.
3.6 Evaluation is conducted.

4.1 A plan for implementation of the training is prepared.

4.2 Training program and curriculum are prepared. 4.3 Lecturers are appointed. 4.4 Teaching materials are prepared. 4.5 The training course is implemented. 4.6 Evaluation is conducted. 5.1 Evaluation for each training course is implemented. 5.2 Level of attainment of the participants is measured. 5.3 The results of the evaluation is taken into account in the succeeding training programs.

Inputs	
Maldives	**Partner/donor**
Personal a. Maldivian counterparts	*Donor agency* Personnel a. chief adviser b. coordinator c. ICT expert Equipment and consumables a. Training room b. Fishing vessel for the practice c. Audio-visual equipment d. Stationaries
Special remarks (Important assumptions, project sustainability, etc.)	

2. Technical Reports as Outputs of the Pilot projects

PP-1. Technical development and verification of live bait catch and holding for improving their survival rate

1) Field technical report of the Pilot Project 1

2) Monitoring survey report of Pilot Project 1 by MNU

Project for Formulation of Master Plan for

Sustainable Fisheries (MASPLAN)

Field technical report of the pilot project 1

Technical development and verification of

live bait catch and holding for improving their survival rate

March, 2017

Morimitsu Ritsuo (Fishing Technology)

Table of contents

1. Outline of Pilot Project

In the offshore fishery sub-sector, “pilot project for technical development and examination of live baitfish catch and holding for improving their survival rate (PP-1)" was implemented with the aim of verifying the validity and effectiveness of master plan development.

In addition, the data and contents obtained from the survey activities of this project will be fully reflected in the Maldives' Fisheries Sector Development Master Plan after sufficient technical consideration.

1.1 The aims of the project and activities

Improve the process from baitfish fishing to loading to live tank with improved fishing equipment. Further improvement of the survival rate of live baitfish is verified by improving the structure of the live bait tank.

Overall Goal : The methods developed are extended among fishers particularly for those of pole-and-line fishery

Project Purpose : Methods to improve live baitfish survival rate in the in-board tank is developed

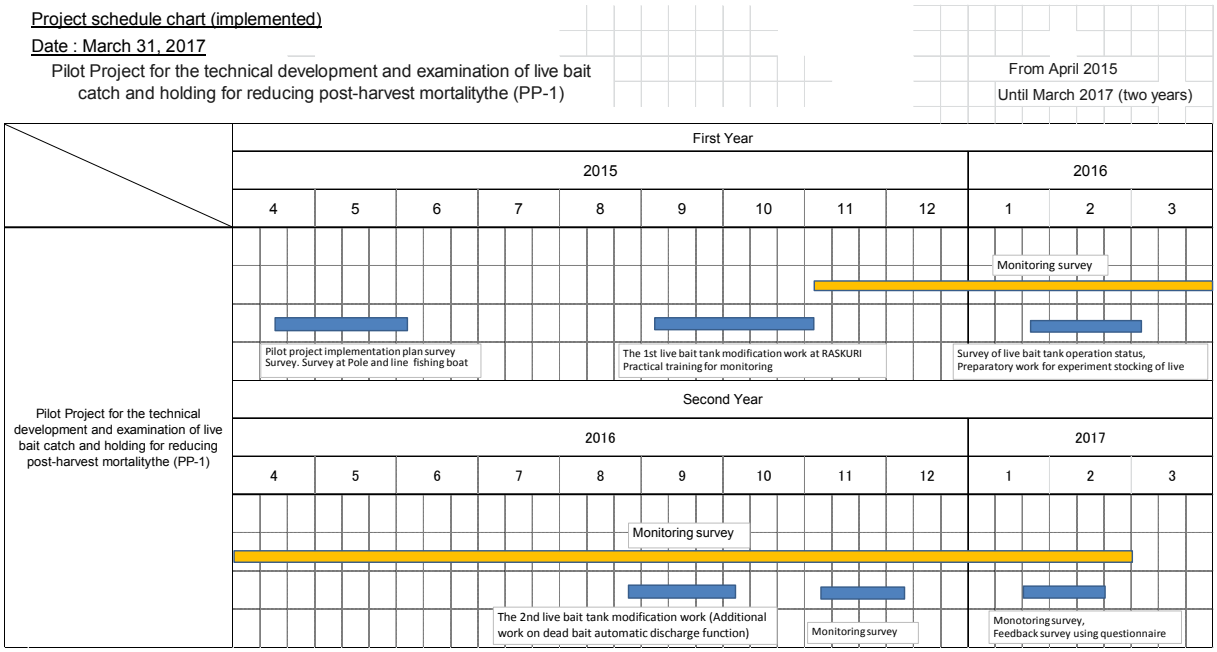
Outputs :
① Fishing gear and methods for catching live baitfish are improved
② The structure and equipment of in-board live bait tank of the experimental fishing boat is remodeled
③Skills of fishers about handling of baitfish are improved
④Survival state of live baitfish in experimental boat is monitored
⑤Conditions of stocking live baitfish in the cage are understood

1.2 Implementation system

[The pilot project for technical development and examination of live baitfish catch and holding for improving their survival rate (PP-1)] was implemented as a joint project by the offshore sub-sector working group (SSWG), Ministry of Fisheries and Agriculture (MoFA), Maldives National University (MNU), JICA consultant team, and fishers of PP-1fishing boat RASKURI.

1.3 Activation process

Table 1: PP-1 Activity Schedule (Implemented)



2. Detailed plan for the project

Implementation of PP-1 was decided at the meeting of the offshore fishery sub-sector and working group (SSWG) which was held from January 20 to March 2015.

For this reason, Morimitsu (fishing technology) and Echigo (fishery resource management) conducted the offshore fishery SSWG pilot project implementation plan survey from April 18th to June 6th 2015. As a result of the survey, a comparison experiment of the survival rate in the bait tank was projected between the live bait tank of the traditional Maldivian fishing boat Dhoni and the remodeled live bait tank proposed by MASPLAN.

2.1 Confirmation of current situation by field survey

In order to preparation of correspondence to PP-1, on-board survey at skipjack pole-and-line fishing boat (Villa Vaali-6) of Horizon Fishery's company (HF Co., Ltd.) and an interview survey in the field were conducted. Based on the survey results, characteristics, problems and differences between the pole and line fishery in Japan and in Maldives were clarified. On-board survey at the skipjack pole-and-line fishing boat was conducted for two days from 26th to 27th April 2015.

Table 2　Differences of skipjack pole-and-line fishery in Japan and in Maldives

Focus points	Japan	Maldives	Remarks
Division of baitfish fishery	Pole and line fishery and live baitfish fishery are divided in two definitely	Pole and line fishers are using self-sufficient live baitfish	Much times and work force are required for collecting baitfish in Maldives
Species of baitfish	Mainly young sardine and anchovy	Kind of sprats and young species in coral reef areas	Sprats are easily captured by photo tactic behavior than sardine and anchovy but easy to die
Habituation and handling of baitfish	Baitfishes are kept in cage net around 1~2weeks before selling to pole and line fishing boat （tamed baitfish）	Baitfishes are loaded directly to the bait tank in the boat after scooped by net（wild baitfish）	Survival rate of wild baitfish is lower than the tamed baitfish in Japan
	Baitfish are transferred to live bait tank in the boat by bucket contained with water	Baitfish are transferred to live bait tank in the boat by scoop net	Modified scoop net can transfer the baitfish with water
Baitfish chumming and water sprinkling	Fisher chums baitfish by signal from master fisherman or own judgment by the condition of fish	Two fishers chum baitfish from right and left gunwale in accordance with fish excitation	Quantity of catches are fluctuated by the technics of fishers and chumming
	A lot of water are sprinkled strongly	Comparatively small quantity of water sprinkling	The amount of baitfish Chumming and water sprinkling affect the catches
Fishing operation style	Fishers sitting on the bow side and catches by pole and line fishing method	Fishers standing up on the stern side and catches fishes by pole and line fishing method	Sitting operation style is more stable in rough sea condition
	There are some rules for the operation like approaching manner to fish school etc.	There are no specific rule for the operation	It is important to avoid conflict between fishers
	Fishing are operated under the halt of boat movement	Fishing are operated under the boat moving condition	If the fishing boat goes to forward while operation, chumming baitfish cannot work effectively
Temperature of fishing area	Around 22～27℃	Around 29℃	Live baitfish survival rate become worse with growing water temperature
Live bait tank structure on the boat	Water level in tank can be kept in high position by compulsory circulating system of water	There is compulsory circulating system. However, water circulation is poor in tank due to inappropriate position of water supply and drainage	Water in tank should be circulated appropriately and stably
	The movement of water in tank is stable even in pitching and rolling of the boat	The movement of water in tank is unstable by the reason of air space in tank	Minimizing water movement in tank is necessary for the improvement of live baitfish survival rate

2.2　Problems concerning of live baitfish survival rate

As a result of on-board survey, it was confirmed that the fundamental problems in the following two points as factors for lowering the live baitfish survival rate in the skipjack pole-and-line fishery.

(1) Handling of baitfish during fishing operation

① There are cases in which baitfish exposed in air when baitfish fishing because the fishing net is light. This phenomenon increases when windy days and waves are high.

② By rushing the fish catch operation of baitfish, the damage such as losing scales are increased by rubbing baitfish with netting.

③ Ordinary scoop net is used to transfer baitfish from fishing net to live bait tank. For this reason, it was thought that the baitfish were exposed in air and then pressed in the scoop net, thereby increasing the mortality rate.

(2) Structure of live bait tank

① Seawater circulation in the tank has not been carried out efficiently because the water supply / drainage points are located at high position in the tank. It was thought that the high mortality was caused by oxygen deficiency in the bottom of the tank.

② For the discharge of dead baitfish, fishers dive into the live bait tank and connect the hose to the scupper (discharge port) at the bottom of the tank so as to discharge dead baitfish. By this process, the amount of dead baitfish cannot be calculated and the fishers give stress to the baitfish by entering the tank.

③ The live bait tank looks like an open pool so the water in the tank is greatly swayed and gives stress to the live baitfish when the boat rolling or pitching.

2.3 Countermeasures for the improvement of live baitfish survival rate and necessary equipment

(1) Basic policy

As a countermeasure against the above-mentioned problems which seems to deteriorate the live baitfish survival rate in live bait tank were introduced as below.

① Remodeling of live bait tank

Remodel the structure of the live bait tank for the purpose of improving the live baitfish survival rate. The remodeling part were mainly 4 points of A) lifting up the hatch height, B) installation of seawater injection pipes to the upper part of the live bait tank, C) installation of a seawater drainage pipe on the bottom of the live bait tank, D)attaching the dead baitfish drainage pipe. Through these remodeling, we aimed to efficient and stable seawater circulation in the live bait tank.

② Improvement of scoop net for baitfish transfer

In Japan, caught baitfish are raised in cage for a certain period (1 to 2 weeks), and transferred from the cage to the fishing boat by bucket containing the seawater so as not to give damage. On the other hand, fishers in Maldives use ordinary scoop net for transferring baitfish from fishing nets to live bait tank. By this method, the fish body is exposed in air and simultaneously gets rubbing damage with the net and other baitfish. In

order to deal with these problems, it was desirable to introduce the modified scoop net that considered work efficiency. The modified scoop net has a regular scoop net shape, but can easily transfer the baitfish with sea water by waterproof cloth which is attached to the bottom of net. As a result of preparing samples of this scoop net in advance and consulting with PP-1 members, introduction of modified scoop net was determined.

③ Stainless steel ring for keeping net space

The water space left in the fishing net sometime became extremely small at the time of baitfish fishing and the phenomenon that the live baitfish was dried out on the sea surface was seen several times. In order to prevent this, small stainless steel ring weight was introduced for keeping underwater space in net at the time of baitfish fishing.

④ Installation of air compressor

Although significant improvement in seawater circulation can be expected by changing seawater supply and drainage piping, we also decided to use the aeration by compressor in order to stabilize the amount of dissolved oxygen in the live bait tank.

(2) Assumed major equipment

Table 3: PP-1 equipment

No	Item name	Maker	Specification · Model	quantity
1	Live bait tank remodeling work	Self-subsistence in Maldives	Rising hatch, remodeling work of water supply and drainage system, Piping	1
2	Bubble generating device	New marine Co.,Ltd	Marine air pumpDHM-60-24V	2
3	Air separation valve	ditto	9ˆ14mm in diameter PVC 3 way type	2
4	Air dispersion stone	ditto	YS-300 hose diameter9 ㎜	4
5	Air hose	ditto	Air hose for live fish 9 ㎜(dia.)×10m(length)	4
6	Dissolved oxygen measure device	Mother tool	Mother tool digital D.O .meter: DO-5509	1
7	Scoop net frame (stainless steel)	Hashida ship yard	400～450 ㎜(diameter) reinforced type, Stainless steel（16mm in diameter)	4
8	Knotless net and waterproof clothe (strong type)	ditto	Diameter of frame400～450 ㎜（Netting in upper, waterproof cloth in lower）	4
9	Scoop net for measurement of live baitfish weight	ditto	450 ㎜(diameter) type, Stainless steel（12mm in diameter) frame in connected with netting.	2
10	Frame for scoop net	Self-subsistence	Wood frame（10 ㎝ in dia.× 2m in length）	4

11	Weight measure (spring type)	Self-subsistence	Mustad	1
12	Stainless steel ring	Self-subsistence	Stainless steel 0.7m diameter ring (9mm in diameter size of stainless steel)	2
13	Stainless steel ring	Self-subsistence	Stainless steel 0.4m diameter ring (9mm in diameter size of stainless steel)	4

Also, based on the schematic drawing of remodeling the live bait tank of " Figure 2: Comparison of structure before and after remodeling of live bait tank", we asked to make a rough estimation of the work to Ali Easa (Senior Engineer) of HF for the plan to remodel the fishing boat at Laamu Atoll HF facility.

(3) Monitoring method

As a result of the meeting with the MASPLAN members after the survey, the PP monitoring method has been adopted the following policy.

In the plan, the JICA technical expert will manage the remodeling of the fishing boat live bait tank in the next two months (August - September, 2015) and instruct the monitoring method to the survey observer. In January - March 2016, the survey and guidance of the progress of monitoring are planned by JICA experts, and the final monitoring result will be analyzed and compiled on September 2016.

① Sample and subject: Since the PP-1 fishing boat is equipped with two live bait tanks, the remodeled live bait tank and unmodified one will be compared the difference in order to measure the effectiveness of the remodeled live bait tank.

② Monitoring survey items: A. Live baitfish loading time, B. Weight per fish type, C. Water temperature, D. Bait fishing operation time, E. Weight of dead baitfish per fish species, F. Record the water temperature at the end of operation

③ Survey form：The form sheet will be prepared by project.

④ Frequency of survey: Twice a month by observer.

⑤ Observer: The survey observer will be selected and dispatched to the PP-1 fishing boat.

⑥ Data compilation: The research team of the university conducting the joint research should submit the monitoring report to MASPLAN within one week after the survey which was contained the recorded data, special notes on the survey and proposals from fishers.

(4) Monitoring implementation system

In order to implementation based on HF, it is essential to establish the implementation system and monitoring system of HF Company. For this reason, we appointed following personnel.

① Person in charge: From the project, we asked to HF for appointing a person in charge who can make coordination and communication for the monitoring survey.

② Survey Observer: As a result of the meeting within the project, it was concluded that it is

desirable to carry out a survey by observer with cooperation from external research institutes. Subsequently, as a result of publicly recruiting collaborative research institutes of the project, applications were made from Villa Collage (Faculty of Marine Studies) and Maldives National University (Faculty of Marine Science). After reviewing the proposals of the two universities, we determined to conduct joint research with the Maldives National University (MNU).

3. PP-1 Change of fishing boat

The new skipjack pole-and-line fishing boat owned by Horizon Fisheries (HF) was designated for PP-1 fishing boat at the time of the SSWG pilot project detailed planning survey conducted from April to June 2015. But after the detailed planning concluded, the difficulty of the cooperation was informed from HF. For that reason, urgent change of the PP-1 fishing boat was decided among the members of the offshore fishery SSWG, and finally skipjack pole-and-line fishing boat of RASKURI in Addu atoll became the PP-1 fishing boat. In the field survey of August 2015, JICA experts and Ali Didi (owner of the fishing boat) had a meeting and agreed on a cooperative system in the project. Due to the influence of reselection work of the PP-1 fishing boat, prepared plan of the project had been changed forcibly and dispatch of JICA expert and activities of PP-1 were postponed for about one month.

Figure 1: PP-1 fishing boat RASKURI

4. Introduction of remodeled live bait tank

4.1 Improvement items

Remodeling of live bait tank was made to RASKURI selected as a PP-1 fishing boat.
The items for remodeling are as follows.

① Lifting up the hatch height

The lifting up of the hatch part has two purposes. The first is to raise the water level inside the tank and minimize damage to live baitfish due to swaying water in the tank. Secondly, adding

discharge pipe for removing dead baitfish from the tank automatically by water pressure in the tank.

② Installation of seawater injection pipe to the upper part of live bait tank
The sea water injection pipe which was made by PVC pipe with many water injection holes has been attached to the upper part of the live bait tank. The pump up sea water is supplied into the live bait tank using this pipe.

③ Installation of sea water drainage pipes from the inner bottom of the live bait tank
Sea water is supplied from the upper part inside the live bait tank and lower part sea water is drained automatically by water pressure in the tank. Also, the surplus sea water is overflowed from the high hatch position through slits and drained. From this efficient seawater circulation system, water quality in the live bait tank is quickly improved.

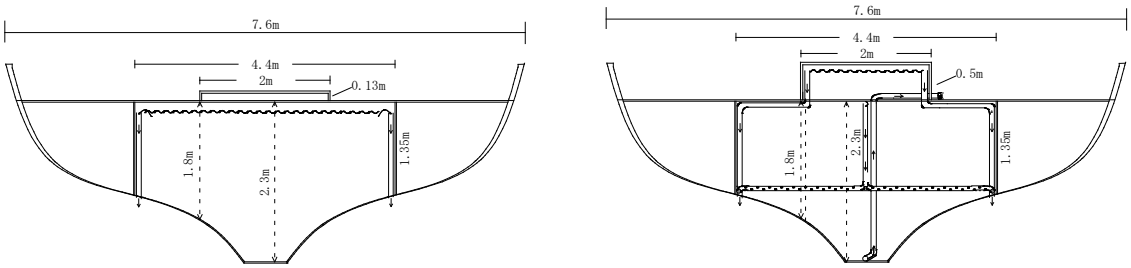
④ Installation of dead baitfish drainage pipe
Improve the method of discharging dead baitfish by new method from the previous method that was done by fishers dive into the live bait tank and collect dead baitfish for discharging. In this method, there is a problem that appropriate water quality control is difficult and stress is given to live baitfish by diver activities in the tank. Also, since the dead baitfish was discharged directly from the bottom of the ship to the sea, it was also impossible to grasp the amount. Therefore, we plan to add a structure to automatically discharge dead baitfish from the bottom of the tank onto the deck. The baitfish which was collected in one place of the tank bottom was automatically discharged onto the deck through the PVC pipe hose by the water pressure obtained by raising the water level inside the tank.

4.2 Design

PP-2 fishing boat RASKURI has 2 tanks of live bait and the stern side live bait tank is used as a main tank which is slightly large in size and has a large water supply sytem. Live bait tank on the bow side are used in case of many baitfish catches or when it is necessary to divide various types of baitfish. The remodeling of live bait tank was decided to stern side by considering the frequency of usage and the workability of the tank.

The capacity of the remodeled live bait tank is as follows.
Live bait tank on the stern side: 27,000 liters (length 3.0 m × width 5.5 m × * height 1.25 m *, 2.4 m *

※ However, the height was measured from the edge of the tank and the deepest part of the tank.



Before remodeling After remodeling

Figure 2: Comparison of structure before and after remodeling of live bait tank

4.3 Remodeling work of live bait tank

The live bait tank remodeling work of RASKURI was carried out twice during the time of religious holiday period by Mr. Ali Rasheed of Addu Atoll as follows.

The 1st period: From September 19, 2015 to October 4 (16 days)
The 2nd period: September 11 - 17, 2016 (7 days)
Place: Fishing Port of Maradhoo in Addu Atoll
Supervisor: Morimitsu Ritsuo (fishery technology)
Contractor: Ali Rasheed
Target boat: RASKURI

The first remodeling work began after JICA expert arrived at the site and explained the concrete construction plan to Mr. Ali Rasheed. The owner Ali Didi arranged Mr. Mvbah of the crew as an English interpreter during the construction period. Remodeling work was carried out from 8 am to past 5 pm even during Ramadan holiday and 2 to 3 fishers of RASKURI constantly assisted the work.

Live bait tank before remodeling

Remodeling work by Mr. Rasheed

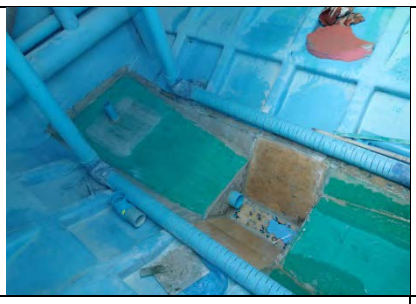
Lifting up work of hatch height

Figure 3: 1st live bait tank remodeling work

The second remodeling work was done to solve the problem that the dead baitfish cannot be automatically discharged well because of incompletion of the first remodeling.

Contents of the remodeling work was to make the slope on the bottom of the live bait tank for collecting dead baitfish in one place and discharge it automatically.

Bottom of the tank before remodeling work



Bottom of the tank under the remodeling work

Completion of the bottom part of the tank

Figure 4: 2nd live bait tank remodeling work

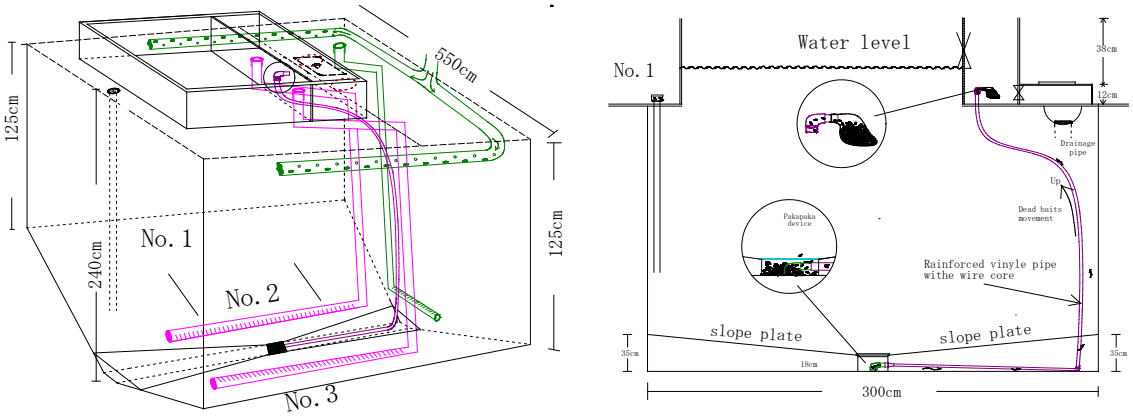


Figure 5: Design of remodeled live bait tank

4.4 Cost of remodeling work

Expenses for the two remodeling works are as follows.

Table 4: Costs for remodeling live bait tank Unit: MVR (Maldives Rufiyaa)

Expense for the live bait tank remodeling work	**Total**	**73,148**	**MVR**
1st live bait tank remodeling work	**Sub-total**	**60,637**	MVR
PVC pipe and others		13,648	MVR
FRP materials		28,989	MVR
Expense for remodeling work		18,000	MVR
2nd live bait tank remodeling work	**Sub-total**	**12,511**	MVR
PVC pipe and others		2,234	MVR
FRP materials		4,877	MVR
Expense for remodeling work		5,400	MVR

(Note: MVR 1 = about 8 yen)

5. Improvement of subsidiary fishing gear etc.

In addition to the introduction of the initially planned modified scoop net, stainless steel ring for keeping net space, water intake pipe with valve and air compressor for aeration were introduced and installed.

5.1 Introduction of modified scoop net for baitfish

Modified scoop net was introduced with the aim of reducing the risk of fish rubbing and damaging fish bodies when transferring them from fishing net to live bait tanks (Fig. 6). This modified scoop net looks like ordinary scoop net, but waterproof fabric is used at the bottom part of the net so that this structure is able to transfer baitfish along with water. As for the modified scoop net, the attachment angle of the handle and the frame was changed by the opinion from the fishers of RASKURI. They said that the angle of scoop net of Maldives is good for handling during the baitfish operation.

As of February 2017 at the end of the project, the fishers of RASKURI are using modified scoop net with utmost care while baitfish handling. In other words, "Practically scoop and transfer quickly with ultimate care" is practiced.

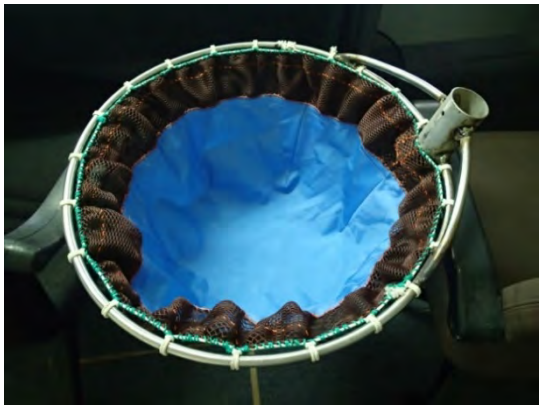


Figure 6：modified scoop net：netting in upper and water proof material in bottom

5.2 Stainless steel ring for keeping net space

PP - 1 fishing boat RASKURI used a square PVC weight for keeping space in the net when catching baitfish, but sometime baitfish come out above the surface of the sea by the reason of light PVC weight.

For dealing with this issue, the project recommended two types of small stainless steel ring weights to secure the underwater space in the net.

Figure 7: Stainless steel ring for keeping net space

5.3 Water intake pipe with check valve

Many skipjack pole-line fishing boats take in sea water from the water intake pipes inserted into the scupper at the bottom of the boat during navigation. On the other hand, when fishers put the large quantity of live baitfish in tank, they use engine pump in order to supply sufficient water and keeping high level of water in tank.

However, if sea water can be taken in from the water intake pipe at the time of high water level in tank, it is useful to save pump fuel and extend the life spun of the pump. For this reason, we attempted to introduce a water intake pipe with a check valve so that sea water does not flow backward. By this trial, though the effect of water intake pipe was recognized, it turned out that the water intake capability declined as the water level rose. It is important to improve this water intake device continually.

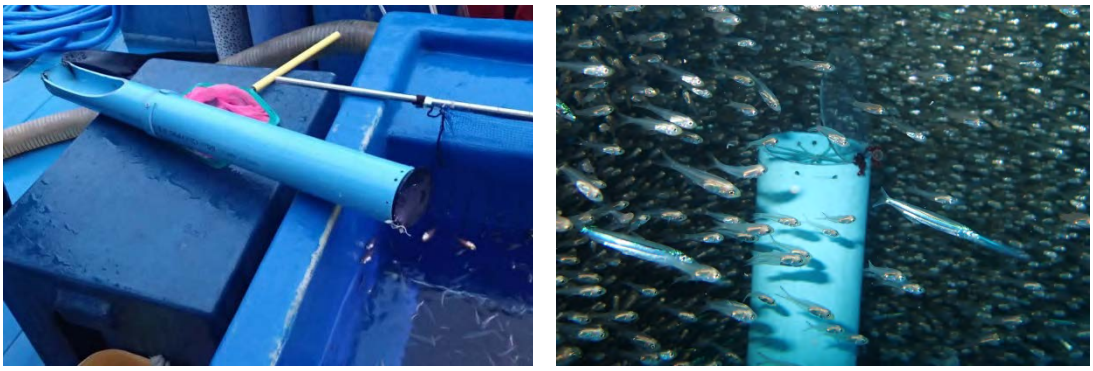


Figure 8: Water intake pipe with check valve

5.4 Installation of air compressor

Efficient sea water circulation system in the live bait tank can be expected by remodeling the live bait tank. In addition, the aeration system by the compressor was planned in order to stabilize the dissolved oxygen even during anchorage in the port. Currently, this equipment is being used at RASKURI in case of necessary situation at port, but since the observer has not been able to investigate at the time of use, it is necessary to verify the degree of effectiveness.

6. Training for fishers and observers

6.1 Training for fishers and observers

At the time of completion of remodeling work of live bait tank and during monitoring survey training was implemented continuously to RASKURI fishers about its operation method. As for the modified scoop net and stainless steel ring for keeping net space, the fishers of PP-1 are handling without any problem.

6.2 Observer's training

(1) Pre-Monitoring Workshop

Prior to the implementation of the monitoring survey, JICA expert had a workshop at the Marine Research Center (MRC) for sharing information, monitoring objectives and implementation systems to monitoring observers from the MNU. The contents of the workshop are as follows.

① Skipjack pole-and-line fishery in Japan (using photo slides and video)
② About the difference between Maldives and Japanese skipjack pole-and-line fishery (by using the detailed plan survey report)
③ Items and methods of monitoring survey.

(2) Training on board

From 3 to 4 October 2015, JICA experts invited two observers to Addu Atoll and provided training on the sea. The items of on-board training are as follows.

① How to fill the survey form
② How to use stainless steel ring for keeping net space
③ How to use modified scoop net
④ Check of sea water circulation system in live bait tank
⑤ Weight measuring method for dead baitfish
⑥ Data processing and circulation after filling survey form

At the first on-board training, the catch of the baitfish had already been completed at the time of observers on board. Therefore, JICA experts instructed the basic monitoring methods such as filling the survey form and checking the sea water circulation system in live bait tank.

In addition, JICA experts carried out the following practical training.

(2-1) From baitfish fishing to baitfish loading to live bait tank

In the PP - 1 fishing boat, modified scoop net proposed from MASPLAN was used to transfer the caught baitfish to the live bait tank. Since modified scoop net can scoop baitfish together with water, so we prepared a large plastic basket separately to measuring the weight of baitfish.

In order to measure the weight of the average weight of baitfish per modified scoop net, the

baitfish was transferred from modified scoop net to the plastic basket floating on the live bait tank, and then the basket was slowly lifted up from the water and the baitfish weight was measured several times.

The total weight of loaded live baitfish can be calculated by multiplying the number of scoop net and average weight of baitfish of one scoop.

In addition, the stainless steel ring for keeping net space proposed by MASPLAN is used not only at the time of baitfish fishing but also collected live baitfish in tank.

(2-2) Observation of sea water circulation in live bait tank

Regarding seawater circulation in the live bait tank, JICA expert taught to observer to pay attention to the following three points.

- ○ Confirm whether the seawater circulation in the live bait tank is operating properly or not.
- ○ Dead baitfish may clog the slits of the drain pipe set in the bottom in tank, so clean it periodically.
- ○ Check the status of live baitfish in tank and overflowing sea water from the side of hatch for making sure it is functioning normally.

(2-3) Measuring the weight of dead baitfish

Periodically take out dead baitfish collected at the bottom of the live bait tank for measuring dead baitfish weight.

Although it is desirable to simultaneously and equally loading baitfish into original and remodeled bait tanks for the purpose of comparing the ratio of dead baitfish, it is difficult to catch enough baitfish all the time. In that case, the interval of the dead baitfish measuring time should be changed by the time of baitfish catching. According to the plan, measuring time of dead baitfish was set to 2 hours, 4 hours, and 6 hours after loading to the live bait tank, but it was changed flexibly by the timing of the skipjack pole-and-line fishing operation.

7. Monitoring survey

7.1 Implementation system of survey

Monitoring survey is based on the MNU team and consists of the following members, but it was prepared to receive assistance from the Sub-sector Working Group (SSWG) appropriately.

Table 5: PP-1 Monitoring Survey Implementation Structure

PP-1fishing boat RASKURI	Owner	Mr. Ali Didi
October 2015 - March 2017	Captain	Mr. Hassan Majudhee
Maldives National University （MNU）	Research Director	Dr. Shazla Mohamed

	Research assistant	Mr. Ibrahim Fikree（MoFA）
	Observer1	Mr. Ibrahim Yameen (MNU)
	Observer2	Mr. Mohamed Mauroof(MNU)
Ministry of fisheries and Agriculture（MoFA）	MRC	Mr. Riyaz Jauharee
	MRC	Mr. Mohamed Ahusan
JICA expert	Fishing technology	Morimitsu Ritsuo
	Fisheries resource management	Echigo Manabu

7.2 Implementation process

The monitoring survey was started after the completion of live bait tank remodeling work that was implemented from September to October 2015. However, several problems were encountered during the monitoring survey. For details of the monitoring implementation status, please see the report from the MNU monitoring team.

7.3 Survival status of live baitfish

The survival rate of live baitfish was compared by measuring the amount of loaded live baitfish and the amount of dead baitfish in each of the remodeled live bait tank and the existing old type live bait tank. As a result of comparison, the survival rate of the remodeled live bait tank was generally better than that of the old type, but the difference was small. As described in the next section "7.4 Issues and Improvements in Monitoring Survey", there is a possibility that the death baitfish amount of old tanks was underestimated due to the problem of monitoring method. On the other hand, fishers evaluated about the effectiveness of remodeled live bait tank as described in the next section "7.5 Project evaluation from fishers (PP-1 fishing boat RASKURI)".

For details, please refer to the report by the MNU monitoring team.

7.4 Issues and Improvements in Monitoring Survey

The monitoring survey was conducted mainly by the MNU student observers but several times they couldn't take monitoring data properly. In addition, due to difficult contact to the student observer since the middle of 2016, JICA expert and research assistant Fikree of the MNU research team responded such as getting on board as an observer. In addition, information and tasks obtained through monitoring were not sufficiently shared among monitoring members. Therefore, the monitoring survey had delayed by failing the on-board timing.

The JICA team discussed the countermeasure with the SSWG and the MNU survey team and asked the MNU survey team to provide sufficient guidance to the observer.

In order not to miss the opportunity to survey further, JICA team requested to MNU to conduct as many monitoring survey as possible by closely contacting with the captain of RASKURI.

The dead baitfish of the remodeled live bait tank can be easily collected, while in the original live bait tank was hard to collect dead bait due to the violent move of sea water in tank. In addition, it was difficult to obtain accurate data because the part of floating dead baitfish flowed out from the overflow drain ports. That is the one of the major reasons of unexpected data comes up from the monitoring survey. Because it was aimed at grasping the survival rate under the condition of actual fishing.However, since the observer was not properly reported, it was not possible to fully grasp the problem at the site and the response was delayed.

In addition to the above, the issues confirmed in the monitoring survey are as follows.

① RASKURI is not easy to adjust the monitoring schedule in order to change the fishing ground according to the fishing conditions.
② There are cases in which catches of live baitfish are few and it is impossible to compare by two live bait tanks at the time of monitoring survey.
③ It is not easy to ensure the necessary amount of live baitfish for monitoring survey, because fishing catches are greatly affected by natural conditions such as tidal currents and moon light etc.
④ The survival rate is greatly affected by the sea condition such as waves even if the fish species of the baitfish are the same.
⑤ There are cases where the schedule of the survey cannot be made in a timely manner by unsmooth contact.
⑥ Monitoring survey could not performed for the number of times scheduled since dispatching of observers was not easy due to irregular fishing operation of RASKURI.

7.5 Project evaluation from fishers (PP-1 fishing boat RASKURI)

In order to obtain qualitative evaluations from RASKURI fishers such as tasks faced in the project and obtained knowledge, questionnaire form was prepared and interviewed.

The main questionnaire items are as follows.

- The remodeling of live bait tank for improvement of live baitfish survival rate (regarding to period, expense, method, technical issues and feasibility of dissemination)
- Usability and impressions of scoop nets and stainless steel ring for keeping net space
- Behaviors and approach of researchers and technicians for monitoring surveys
- Method, time and period of monitoring surveys, and catch amount of live baitfish
- Communication system with MNU for monitoring surveys
- Countermeasure required for improvement of live baitfish survival rate

The interviews showed that some crews highly evaluated the remodeled tank, the scoop net and stainless steel ring for keeping space after they actually made use of those for more than one year. In particular, the remodeled live bait tank had an impact as new technology to the crews such as automatic drainage of dead baitfish from the bottom of the tank with water pressure. In addition, the crews evaluated that the remodeled tank has capability of long-term live baitfish survival. On the other hand, they proposed further remodeling of the tank for expanding hatch size for easy handling, and more watering pumps aiming to supply enough oxygen in case of a lot of baitfish in the tank.

Table 6: Summary of interviews

Question	Very good	good	Ordinary	Bad	Very bad	Total
Is the new live bait tank easy to use?	10	5	0	0	0	15
Is modified scoop net easy to use?	11	2	2	0	0	15
Is the stainless steel ring convenient for keeping net space?	11	1	3	0	0	15
How about the monitoring survey method?	13	1	1	0	0	15
How was the communication system with MNU's monitoring team?	13	2	0	0	0	15

For the interview survey results, please refer to Appendix 1 "The total result of questionnaire for the improvement of live baitfish survival rate (PP-1)".

The remodeled tank, scoop nets and stainless steel ring for keeping net space produced the following improvement:

(1) The status of live baitfish can be easily confirmed since the sea level in the live bait tank rises and the water surface becomes stable.
(2) Water quality becomes better as dead baitfish is automatically drained from the bottom of the tank;
(3) Live baitfish becomes more fresh and lives longer as the seawater circulation is stable in the remodeled tank, while it is difficult to keep live baitfish fresh in a normal tank for a long time;

(4) The net-retaining rings (stainless steel ring for keeping net space) can secure the net configuration in the water during fishing operation. Though it becomes heavier than before, the stress to live baitfish has reduced.
(5) Live baitfish in the tank clearly observed with an underwater light and live baitfish swims calmly and keeps the good condition without stress
(6) The modified scoop nets reduced the stress and damage of scratch of live baitfish.
(7) Automatic drainage system of dead baitfish can also reduce the number of diving into the tank. Not only stress to fish but also labor work of crew was reduced.

7.6 Other findings obtained through project implementation

(1) Selection of the project fishing boat

The vessel designated at the beginning of the project had altered for unexpected reasons. This caused change of the agreed plan of the project, which required considerable amounts of time and effort. Considering the matters like this, it is necessary to comply with necessary requirements beforehand and to have political consideration in advance when selecting a project fishing boat. Establishment of cooperation system with a vessel owner and crews is also an important factor in terms of selection of the project fishing boat.

(2) Project site

RASKURI finally determined as the project fishing boat that based at the Maradhoo as homeport for skipjack pole-and-line fishing around Addu Atoll. In this Atoll, there is the second largest populated city in the country where materials and engineers necessary for the remodeling work of the tank are available. In addition, it takes 1h20 by air between Addu Atoll and the capital Male with five flights a day. For these reasons, Addu Atoll was suited for the project site.

(3) Authorization and agreement on the remodeling work of the live bait tank

The remodeling work of the RASKURI's live bait tank was authorized by boat owner and started after the explanation of work plan and drawing by the JICA expert. The owner was interested in new technologies. Participation of such a motivated owner in the project was a key factor for establishment of cooperation system for project implementation.

(4) Issues of monitoring surveys

Monitoring surveys were conducted in cooperation with MNU observers. However, they sometimes failed to go through the proper procedure and collect data, and sometimes we could not get in contact with them from the middle of 2016. For this, JICA expert or Mr. Fikree research assistant carried out the monitoring surveys. During the surveys, we found out that dead bait fish from the remodeled tank could be collected easily, while it was difficult to collect dead bait

fish from the bottom of the original tank. JICA expert tried to load the catch both in the remodeled tank and in the original, but in many cases, the catch was not so much and loaded only in the remodeled tank. Therefore, the data was not sufficient to compare the two tanks. In addition, JICA expert repeatedly asked the college student observers to make reports if any problems during the monitoring surveys, but there was no indication from them. Actually, it was difficult for JICA expert to find out the way to retrieve dead bait fish efficiently from the bottom of the original tank due to its structural problem. Therefore, JICA expert should have tried to find a fundamental solution such as total revision of the plan of monitoring surveys. At last, the number of the monitoring surveys organized by MNU was less than planned due to insufficient communication and coordination with RASKURI and observers.

(5) Seasonal fluctuation of the catch of live baitfish

The project site Addu Atoll has few resources of live baitfish indispensable to skipjack pole-and-line fishing, and so RASKURI caught live baitfish around South Huvadhoo Atoll located 6 hours in the north from Addu Atoll because of seasonal fluctuation of resources of live baitfish.

Especially from June 2016 to around September, it was a low fishing season so the RASKURI had to navigate for live baitfish as far as the north of Male Atoll during that period. It is the dilemma that there are abundant resources of skipjack in particular in the area of Addu Atoll, and to the contrary, it is difficult to catch live baitfish in the same area. In the long-term perspective, it is crucial for resources management of live baitfish to improve survival rate of live baitfish and alleviate environmental pressure to the resources by reducing the number of baitfish fishing operations; that is the aim of the project.

(6) Monitoring survey under the full tank of baitfish

JICA expert conducted the second survey from January 24 to 29 2017. During the survey period, both the remodeled live bait tank and the original live bait tank were almost fully loaded with about 400kg of baitfish in each. Even under this situation, the remodeled tank was able to weigh the dead baitfish by the automatic drain system. On the other hand, the dead baitfish in the original tank could not be collected with a scoop net for measuring its weight. For these reasons, it was not measured the weight of dead fish until four hours after catch and to compare the survival rate of live baitfish, then monitoring had continued around three hours before the crews worked on skipjack pole-and-line fishing. Therefore, it was difficult during this monitoring survey to collect data accurately enough to compare the survival rates of live baitfish between the remodeled tank and the original one.

8. The experiment of baitfish farming in cage net

Formerly, skipjack pole-and-line fishers in Maldives cultured live baitfish in cage when fishing boats returning to the port with live baitfish, but currently only occasionally can be seen. Because, the capacity of the live bait tank of fishing boat became larger along with the enlargement of fishing boat. As a result of that the live baitfish can easily be kept in the live bait tank until the next sea going operation. Meanwhile, the skipjack fishing ground of Addu Atoll area is popular among skipjack fishers but the scale of the atoll is small and the reef area that is the fishing ground for the baitfish is also small.

For this reason, there are many periods of insufficient baitfish catch times around the atoll.

In such a case, fishers need to travel to other Atoll for catching the baitfish and go from there to the fishing ground of skipjack, so the problems of losing time and fishing chance plus increasing trip expenses occur. Such a situation is also seen in other atolls, which become a burden on the management of skipjack pole-and-line fishery.

Sometimes the fishing boats keep the baitfish in the tank after returning to the port, in that case, it is necessary to operate the engine pump which requires fuel cost during the anchoring.

In addition, it was considered that there are many baitfishes that die in the live bait tank and wasteful use of resources was pointed out. Coping with these situations, we planned a live baitfish farming experiment using cage net which seems to be useful for effective utilization of baitfish resources.

This experiment was scheduled to be carried out from September 2016 to March 2017 using the MRC facility on the south Male Atoll Maniafushi Island, with the following system.

Table 7: Members responsible for experimental study

Name	Position	Title
Mr. A Riyaz Jauhary	Project leader	MRC/ Oceanic fisheries
Mr. A Riyaz Jauhary	Data collecting & other filed work	MRC/ Oceanic fisheries
Mr. Morimitsu Ritsuo	Technical Adviser (Planning & technology)	JICA expert
Mr. Echigo Manabu	Technical Adviser (Analysing)	JICA expert

8.1 Purpose and method of the experiment

This feasibility study was planned for the purpose of reducing the number of times of baitfish fishing of skipjack pole-and-line fishing boats by farming baitfish for a certain period of time, and also reducing wasteful consumption of baitfish resources. From this plan, economic and efficient fishery management will be implemented.

Preparation for experiment such as cage frame, cage net design and installation work on the sea was done by JICA expert, and Mr. Riyaz of MRC became responsible for the experiment. In the experiment, the baitfish was placed in cage net and investigated both survival rate and that period.

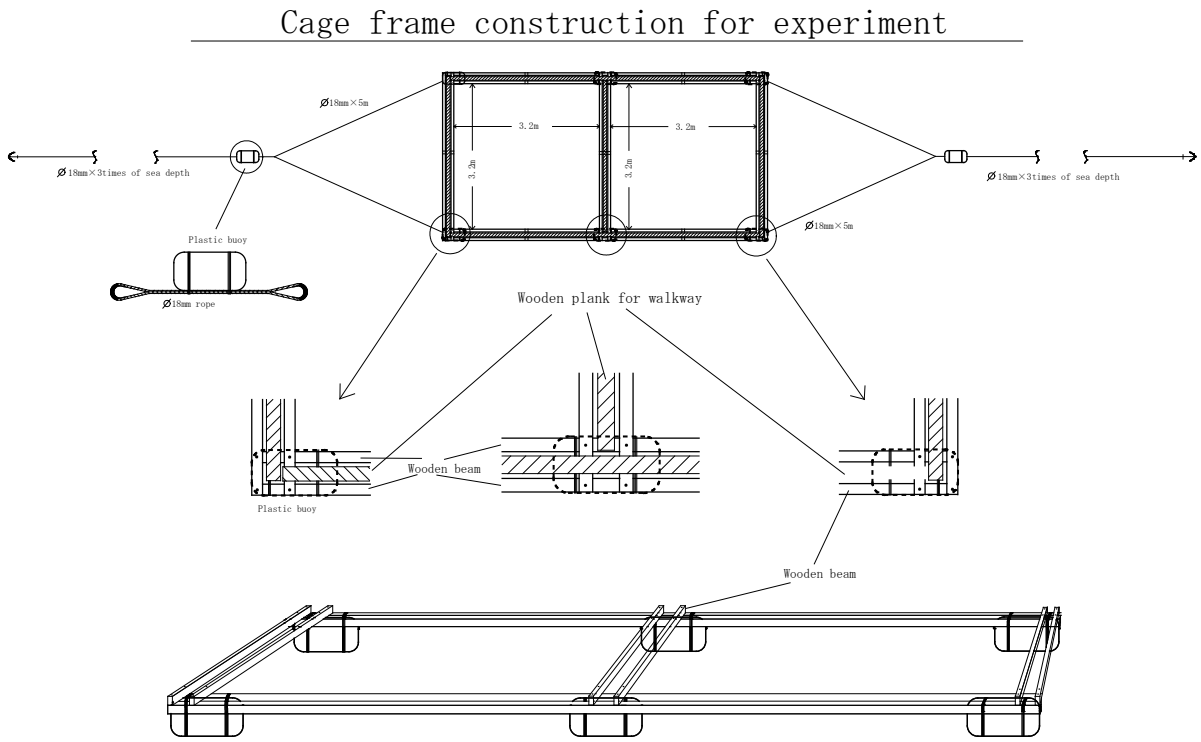


Figure 9 Structure of cage frame

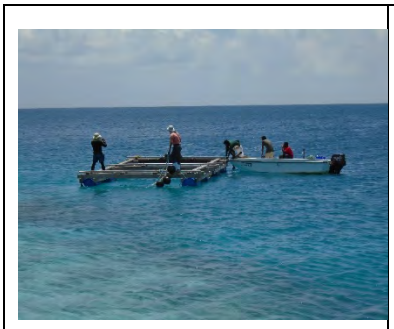
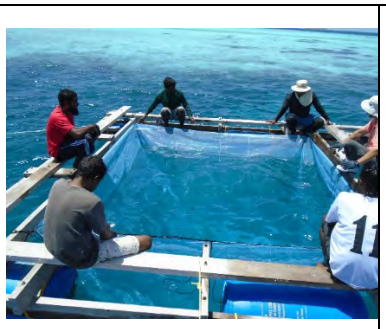
		
Fixing work of the cage	Netting Attachment work	Installed cage net in the sea

Figure 10: Cage net setting work

8.2 Result of experiment

The first experiment of the baitfish was done on 10th December 2017. At that time, about 100 kg of baitfish (kind of Apogon lineatus) were placed to one cage. Baitfishes were fed a breeding feed (made in Japan) immediately after placing the baitfish in cage net, but the baitfish gradually

became weak without eating the mixed feed and gradually decreased in number. Eventually, all baitfish has died out after 10 days.

This experiment was planned to investigate the weight of dead baitfish after collected using scoop net by diver (researcher) in the cage net. However, it was very difficult to collect all the dead bait inside the cage net, and quantitative data could not be obtained.

After that, during the period until March 2017, the experiment member frequently planned to place baitfish to cage net, but failed to procure baitfish for the following reasons.

1, Fishers refused to sell because it was poor baitfish season. 2, the distributor presented the extremely high price of baitfish. For these reasons, it was impossible to conduct substantial experiments and it was impossible to achieve results within the PP period. In future, MoFA / MRC have a plan to continue the experiment.

8.3 Future tasks

The area where baitfish farming experiment was carried out face the open ocean and was not suitable for baitfish farming in a situation that is directly affected by wind and waves.

The fish farming in such a place is not only easy to damage the cage facilities, but also the baitfish rubbed with cage net. Therefore, the mortality rate of the baitfish increases. For these reasons, we should choose the calm sea condition areas for the baitfish farming experiment such as inlet or the inside of the bay.

From the person in charge of experiments, it was pointed out that it is necessary to remodel the cage net for removing dead baitfishes from the outside of cage net and install an opening / closing discharge port after making slope at the bottom of the cage net. In addition to these points, it is necessary to consider the easy procurement season of baitfish for survey.

Furthermore, in order to conduct experimental baitfish farming, it is essential the person who has capable of performing experiments with responsibility and sufficient knowledge and experience of baitfish.

9. Future tasks and recommendations

9.1 Overall evaluation

This pilot project (PP - 1) was practically implemented from April 2015 until March 2017. Meanwhile, we have grasped the problems by field survey, examined and planned countermeasures, remodeled live bait tanks, prepared necessary materials and conducted monitoring surveys. In addition, we also supported the experiment of baitfish farming using cage net for sustainable use of baitfish resource.

JICA experts were able to finish the project safely by cooperating with the JICA team, MoFA, MNU and the crews of PP-1 fishing boat RASKURI. Of course, several issues were discovered and the best response was made each time during the project period.

However, due to the structural problem of the original live bait tank, problems such as the inability to properly collect monitoring data and the number of monitoring times planned could not be gathered. On the other hand, in the interview survey conducted to the PP-1 fishers at the end of the project in March 2017, the effectiveness of the remodeling of the live bait tank proposed by the project, the water intake pipe and the stainless steel ring for keeping net space were confirmed.

The expenses such as fuel and food for every fishing trip are applied for the operation cost of RASKURI. In addition to that, income from the skipjack pole-and-line fishery supports the life of nearly 20 crew members and their families. Under such circumstances, it is natural that the planned project activities also have certain restrictions, therefore sometimes we felt a sense of difficulty in monitoring survey at PP-1 fishing boat.

From such a point of view, it is necessary to take measures for preventing the loss of dead baitfish away with drainage water. For the collection of more detail data in the future, we should pay the necessary expenses for charter fishing boats and conduct surveys without fishing operation.

9.2 Recommendations concerning future survey

Skipjack pole-and-line fishery in Maldives has developed with a long history and still the main industry of the country. On the other hand, there are problems to overcome such as reduction of wasteful use of baitfish in order to sustainable skipjack pole-and-line fishery. In the project of PP-1, we examined how to keep the baitfish in the tank, which is an indispensable element of the skipjack pole-and-line fishery. Through monitoring surveys, although there was no clear difference in the survival rates of the newly remodeled live bait tank and original tank, several effective results were obtained as qualitative evaluations from fishers. Based on these circumstances, person in charge for baitfish should continue to investigate and research for improving the survival rate of baitfish in the tank for skipjack pole-and-line industry in Maldives. Of course, support from Maldives government is also important.

In the PP-1 project, JICA experts were dispatched six times for planning, preparation, implementation and monitoring survey in the short term in each. In that case, it became difficult to respond to sudden plan change during the period when the expert was not in the field. In Maldives, it should be taken into account that there are many requirements in advance such as stakeholder consent and political consideration etc.

9.3 Feasibility of new technologies for improvement of survival rate of live baitfish

Recommendation from the pilot project is to introduce Japanese-model remodeled live bait tank, scoop nets and net-retaining rings. To evaluate the PP-1, the interviews with the captain and crews of RASKURI by questionnaire were conducted. The interviews showed that the each of introduction was feasible for fishers in Maldives because the scoop nets and net-retaining

rings are not expensive and the system and functions of the Japanese-model tank will be most likely introduced to local fishers with a good reputation. The points to be noted for introduction are as follows:

(1) The hatch of the live bait tank should be large enough to collect baitfish in the tank during the skipjack pole-and line fishing operations
(2) The bottom of the live bait tank should have a pitch so that all dead fish gather at a discharge slot and can be smoothly drained;
(3) The discharge slot of the dead baitfish should have a strainer so that live baitfish cannot be drained
(4) There is a little dissolved oxygen in seawater in Maldives through a year due to high temperature of seawater. Therefore, the amounts of live baitfish should be determined in relation to the volume of the tank as well as the quantity of seawater to be supplied
(5) In case of fitting slit discharge pipe in the bottom of the tank, the position of the pipes should be adjusted properly for easy scooping baitfish during fishing operations
(6) Dissolved oxygen in the live bait tank can be increased by means of aeration with air mixed into seawater to be supplied into the tank
(7) Do not set pipes in the live bait tank in order to make Japanese system when building a new boat. The tank should be also designed to drain dead baitfish automatically and keep clean seawater in the tank. The bottom of the tank should have a pitch so that all dead fish gather at one place and can be easily discharged
(8) It is more difficult to take seawater from intake pipe attached in the bottom of tank when the large distance between seawater surface and water intake pipe. Therefore, the distance should be carefully considered in case of taking seawater from the bottom of the tank while skipjack pole-and-line fishing boat navigating.
(9) The design of Japanese-model live bait tanks is to circulate seawater from the upper to the bottom in the tank. Supplied seawater from the upper side is discharged to outside automatically from the bottom of the tank by water pressure. In addition, the flow of the seawater is set in the direction to the wall of the tank so that the seawater will not directly hit baitfish in the tank.

Based on the above contents, positive promotion plan of MoFA for research and dissemination of remodeled live bait tank is important.

Regarding to the dissemination, the effective results can be obtained by focusing on Addu atoll in southern part where the procurement of baitfish is severe by poor baitfish resources for skipjack pole-and-line fishing throughout the year.

9.4 Recommendations for skipjack pole-and-line fishery

The following is the list of recommendations realized through the pilot project activities in

terms of skipjack pole-and-line fishing itself. Most of them are related to specification of a fishing boat such as the strength of hull and type of shape:

(1) Most fishing boats are equipped with a large tank for live baitfish, but its strength is not sufficient. An accident is likely to occur that ocean waves may separate the stem and stern of a boat. To prevent this kind of accident, the owners and shipbuilders should reconsider to enhance the strength of fishing boats. Also, the Government should set up new standards for shipbuilding

(2) Most of large fishing boats have bridges with two to three level decks, and so the positions of the center of balance are high. For this reason, the fishing boats are subject to rolling from side to side. The measure to cope with such rolling should be taken.

(3) Most of skipjack pole-and-line fishing boats are equipped with GPS and fish finders, but the other fishing instruments such an electronic water thermometer are limited for only a few fishing boats. With a view to stability of fish catch and management, it is useful to introduce higher-performance GPS, fish finders, electronic water thermometers and sonars.

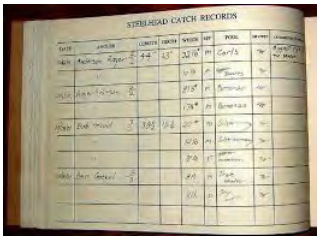
				
Fish Finder	Sonar	Radar	Electric Water Thermometer	Logbook

Figure-11: Electronic Instruments and Logbook for Skipjack pole-and-line Fishing

(4) Schools of skipjack are likely to move seasonally to specified areas. Recorded logbook for fishing operation and the accumulated information must be useful for improvement of fishing efficiency. In Japan, most fishers determine the fishing ground of the day after consideration of the information from the logbook as well as the water temperature. Therefore, it is desirable that more fishers in Maldives should use electronic water thermometer to find out the best fishing ground for skipjack.

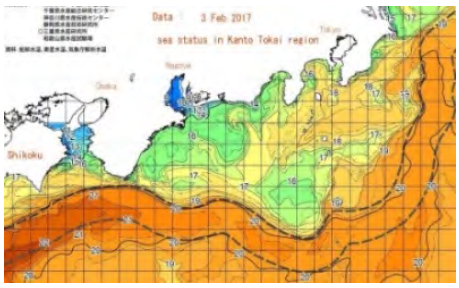


Figure-12: Water Temperature Distribution (Source: Wakayama Fisheries Experiment Station)

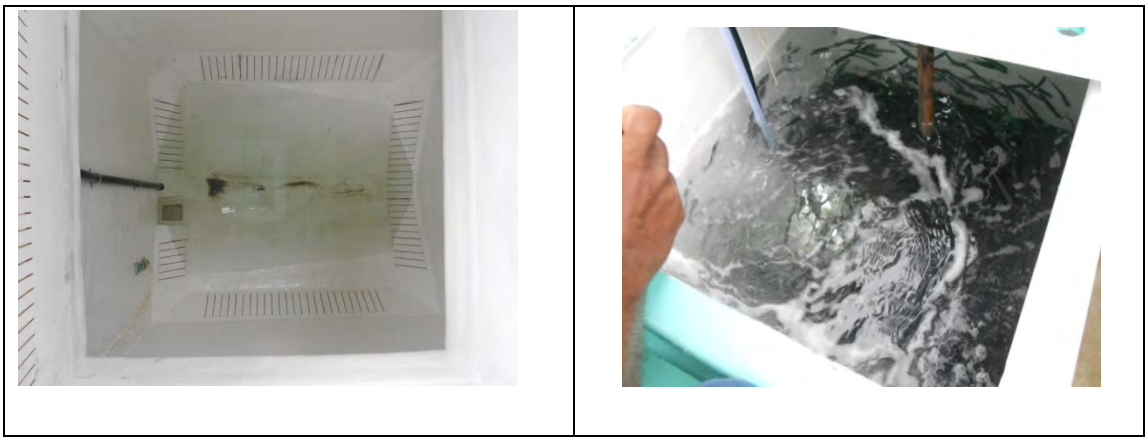


Figure-13：Live bait tank of a Japanese fishing boat for skipjack pole-and-line

(5) The seawater cooling circulation systems have been already introduced in some fishing boats in Maldives. Using this system, no/little ice is required for cooling fish catch, and therefore the time, labor and expenditure for ice are reduced. In addition, more freshness of fish can be also expected. Initial cost for purchase and installation of the system is required, but it is worth considering its introduction.

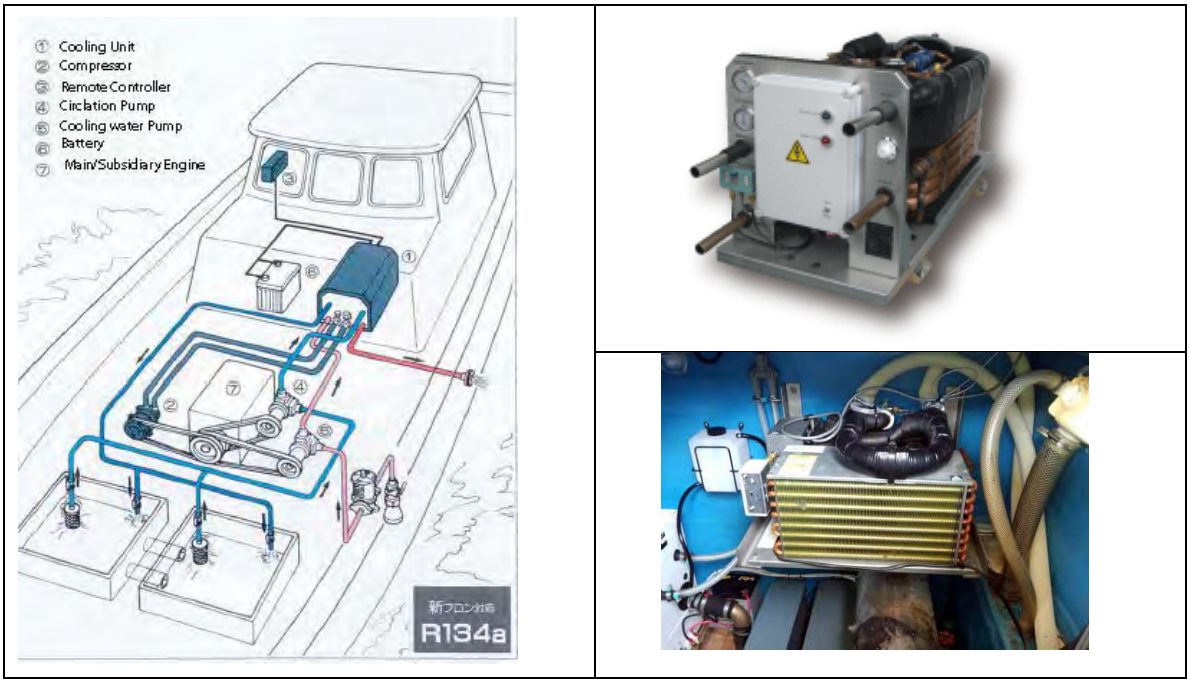


Figure-14: Seawater Cooling Circulation System

(6) Fish hold tanks for storing catch fabricated with insulating materials can keep cool inside the tank. Highly insulated tanks contribute to reduction of cost of ice and keeping quality of fish catch.

(7) Fishing boats are subject to pitching and rolling from wind and waves at sea. In a larger fish tank, skipjack caught may rub and jostle each other in the tank, which causes deterioration in quality. In such cases, downsizing the tank is important for keeping fish quality so that fish

catch cannot move inside the tank while navigating.

(8) The ratio of fish catch per chumming bait is lower in skipjack pole-and-line of Maldives than of Japan and Southeast Asia. The cause of such inefficiency should be investigated and be improved the fishing method itself accordingly.

9.5 Recommendations in terms of economy and sustainability

During the project implementation, many fishers of skipjack pole-and-line said that the resources of baitfish had been diminished. This may result from increasing pressure of baitfish catch to the resources of baitfish, arising from enlargement of the size and increase of the number of skipjack fishing boats. Under this situation, it is an important issue for skipjack pole-and-line fishery in Maldives to utilize the resources of baitfish efficiently, and one of the initiatives was this pilot project aiming for improvement of survival rate of live baitfish. It will be crucial for sustainable fishing to properly manage and control the size and number of skipjack pole-and-line fishing boats.

Furthermore, in terms of the above-mentioned “Feasibility for new technologies for improvement of survival rate of live baitfish” and “Recommendations for skipjack pole-and-line fishing”, it will be also crucial to consider expenditure and fish prices to cover introduction of equipment and facilities from a practical viewpoint of fisheries business administration. The comprehensive management should be realized so that the development of sustainable skipjack pole-and-line fishing will be promoted.

End

Appendix 1: The result of qualitative evaluating by fishers

from RASKURI fishers　　15 samples in total

1 The impression of the entire this pilot project.

		Very good	Good	Ordinarily	bad	very bad	Total
①	Is it easy to handle the modified live baitfish tank ?	10	5	0	0	0	15
②	Is it easy to handle the scoop net with water ?	11	2	2	0	0	15
③	Is it convenient to use the stainless steel ring weight ?	11	1	3	0	0	15
④	How was the monitoring method ?	13	1	1	0	0	15
⑤	How was the communication system from MNU monitoring team ?	13	2	0	0	0	15
⑤	How was the working manner of monitoring observer ?	13	2	0	0	0	15
⑥	How was the working manner of expert ?	14	1	0	0	0	15

2 Please describe your impression of the modified live baitfish tank ?

1.[As our boat was already prepared with traditional baitfish well, its little bit difficult to handle. But I highly recommend this method for new boat.] 2.[working very well. Need to modify the opening of baitfish well. Its too small] 3.[worked very well for some kind of baitfish. cost for maintenance is higher but is worth it. can be prepared much better now] 4.[This tank was very good and easy to live baitfish.] 5.[its very good project but the tank when we modified it was bit small for the mouth.] 6.[its very good for us and we got new information.] 7.[very good] 8.[its good] 9.[its good automatically removing of dead baitfish is very easy for me. water circulation is easy.] 10.[sometimes live baitfish also coming through the strainer with dead bait.] 11.[it is very good] 12.[its good, its easy to handle baitfish durig the dark because of the light whice is inside the tank.] 13.[its easy to handle modified baitfish tank. really easy when the dead bait is automatically removed.] 14.[its good for me] 15.[modified tank mouth is too small.]

3 Did you get any new information or knowledge from this project ?

Yes	No
15	0

In case of [Yes], please describe it.

1.[The whole system is new information I got form the project specially the drainage system is new.] 2.[dead bait is automatically removed.] 3.[The whole system is the new information I got] 4.[when the current of the sea is high, its easy to carry baitfish in that tank.] 5.[No need to dive, to remove dead baitfish.] 6.[water pipe arrangement is really very good.] 7.[The whole system is new for me.] 8.[the whole system new for me.] 9.[dead baitfish automatically removing is new for me.] 10.[The whole project is new for us specially the removing of dead baitfish.] 11.[Yes: its easy to live baitfish in this tank and live more longer than other tank.] 12.[Yes:this project was very good for new dhoni because its little bit hard work and many pipe inside the tank] 13.[I learned that we are not the only people who handle live baitfish and that we have other type of baitwells. I know how to prepare the modified baitwell now.] 14.[Baitfishes are dying because of less oxgen. its better to light the baitwell from inside than from top.] 15.[learned that traditional baitwell has bad water circulation. the new scoop net with water is very good for live bait.]

4 Is it possible to accept the modified live baitfish tank system to other dhoni, do you think ?

Yes	No
15	0

[Reference]: total expenditure for the modification works of RASKURI was 72,000MRf

5 What is necessary for the improvement of live baitfish survival rate in the future, do you think?

1.[when building new baitwell, we should install water proof lights and add more water pumps.] 2.[to prepare the baitwells bigger. Put more oxgen pumps.] 3.[Higher capacity pumps. More oxgen pump. Good quarity material for scoop net.] 4.[more piece pump we need our tank.modified tank mouth was smaller than the other tank.] 5.[Need more pump and oxgen pump for the tank because its its very small mouth the tank.] 6.[space of the tank should be big.] 7.[the light which is inside the tank should be more bright.] 8.[the bait tank should be more big so the bait will have more space.] 9.[the mouth of the tank should be big.] 10.[Tank mouth should be more bigger.] 11.[more water should come from the pipe.] 12.[water pipe should be less and pipe should be more inside.] 13.[Drainage pipe should be more big.(long) because when its small more easily the pipe is blocked by dead baitfish.] 14.[modified tank mouth should be big, because when its small very difficult to handle.] 15.[Pipe line should be more inside the tank so that there will be more space inside the tank. because of the light inside the tank we are able to put more baitfish.]

6 Please write your additional opinion etc. if you have anything.

1.[Ice plants in each island. High prices for fish. More quality equipments.] 2.[to get more opportunities for fishermen to learn from other countries.] 3.[We should let foreigners buy tuna from maldivian fishierman for high pay checks.] 4.[more ice.] 5.[we should get more ice.] 6.[we should get enough ice.] 7.[more ice.] 8.[we need more technology. latest equipments.] 9.[we should get more ice.] 10.[we should get more ice.] 11.[more ice for the fisherman and latest equipments.] 12.[more ice plants. when we purchase fish we should get enough ice.]

7 Which tank can baitfish survive longer in case of 3 days after, do you think?

	Modified tank	Original tank
Please check it	15	0

Project for the Formulation of Master Plan for
Sustainable Fisheries

Monitoring Survey Report of Pilot Project 1

Technical development and verification of live bait catch and holding for improving their survival rate

Dr Shazla Mohamed
Ibrahim Fikry
The Maldives National University

March 2017

Contents

Technical development and examination of live bait catch and holding for reducing post-harvest mortality

1 Background

MASPLAN is a JICA-MoFA project aimed at to formulate a mid- and long-term development plan for the fisheries sector in the Maldives. Considered as the Fisheries Sector Master Plan, it will support the promotion of fisheries based on the philosophy of persistent and efficient use of fishery resources in a sustainable manner. In addition, this plan is also expected to contribute to long-term environmental management and support the promotion of tourism through sustainable utilization of fisheries resources.

A major focus area of the project is the skipjack tuna pole-and-line fishery and hand line fishery for yellow-fin tuna. The skipjack tuna pole-and-line fishery is the most important fishery of the country accounting for 60% (71,000 tonnes in 2013) of gross fish catch in Maldives. A major issue is the high mortality of live bait (anchovy, spratelloides etc.) which is essential for the skipjack tuna pole-and-line fishing methodology. This project examines options for improving fishing methods for bait fish and efficiency of water circulation in the tank to ensure higher survival rates.

The outputs of this project conducted as collaborative work between JICA-MRC-MNU are to improve bait fishery and usage of bait fish by:

a. Effective onboard handling and modification of fishing gear for improving live bait fishing operation
b. Modification of the bait tank for efficient water circulation and reduced mortality of bait fish

The study intends to compare changes in the mortality rate between the currently practicing method and the modified method. For this purpose, one tank of the fishing boat was modified while the other unmodified tank was used as a control. Other alterations to the fishing gear such as modification of the scoop net and improvements to the handling methods would be considered.

1.1 Preliminary study onboard

(1) Study site ：Horizon Fisheries (HF) located at Maandhoo Fisheries Complex
(2) Project area: Laamu Atoll
(3) Fishing boat：Owned by Horizon Fisheries（under the fishing boat registration）
(4) Period of study: April 2015

On board survey and consultation with Fishers was carried out on the boat of HF to compare and understand the differences between pole and line fishery of Maldives and Japan (Table 1). This survey revealed the key points for improvement of baitfish survival rate used in the Maldives pole and line fishery.

Table1: Differences between skipjack pole and line fishery of Japan and Maldives

Focus points	Japan	Maldives	Remarks
Division of bait fishery	Pole and line fishery and live bait fishery are two distinct fisheries	Pole and line fishers catch the live bait	More time and effort are required for collecting bait fish in Maldives
Species of bait	Mainly young sardine and anchovy	Two species of sprats and various small reef associated species	Sprats are easily captured by photo tactic behavior than sardine and anchovy but have a higher post-harvest mortality
Habituation and handling of bait fish	Bait fishes are kept in cage net for ~1-2weeks before selling to pole and line fishing boat （tamed bait）	Bait fishes are loaded directly to the bait tank in the boat after scooped by net （wild bait）	Survival rate of wild bait is lower than the tamed bait in Japan
	Baitfish are transferred to live bait tank in the boat by bucket contained with water	Baitfish are transferred to live bait tank in the boat by scoop net	Modified scoop net can transfer the baitfish with water
Baitfish chumming and water sprinkling	Fisher chums baitfish by signal from master fisherman or own judgment by the condition of fish	Two fishers chum baitfish from right and left gunwale based on the excitement level of the fish	Quantity of catch varies based on the experience and technique of fishers and chumming
	A lot of water are sprinkled strongly	Comparatively small quantity of water sprinkling	The amount of bait chumming and water sprinkling affect the catches
Fishing operation style	Fishers sitting at the bow and operate pole and line to fish	Fishers standing up at the stern to operate the pole and line	Sitting style is more stable in rough sea condition
	There are some rules for the operation like approaching manner to fish school etc.	There are no specific rule for the operation	It is important to avoid conflict between fishers
	the boat is stopped during the fishing operation	the boat maintained movement during the fishing operation	If the fishing boat moves forward while in operation, chumming bait is not effective
Temperature of fishing area	Around 22 to 27℃	Around 29℃	Live baitfish survival rate decreases with growing water temperature
Live bait tank structure on the boat	Water level in tank can be kept in high position by a dedicated circulating system of water	There is dedicated circulating system. However, water circulation is poor in tank due to inappropriate position of water supply and drainage	Water in tank should be circulated appropriately
	The movement of water in tank is stable even in pitching and rolling of the boat	The movement of water in tank is unstable due to the air space in tank	Minimizing water movement in tank is necessary for the improvement of live bait survival rate

From the results of on board survey, two key factors for low survival rate of live bait were identified. That is poor handling of baitfish and inappropriate structure of live bait tank, as described below.

(1) During bait fishing operation

- Some of the bait caught is exposed to air, while at the sea surface and before being hauled onto the boat, especially in windy conditions due to the lightweight material of

the net.

- Bait fish were handled in a rush and rough handling was evident at the time of operation. Therefore, vulnerable species of bait fish were easily damaged by friction with the net.
- It was observed that a high mortality of bait fish is caused under the pressure in scoop net when transferring from catching net to the tank in the boat.
- The scoop nets which were used are holding 90 degree angle between the net frames and handle so that it has the advantage of easily scooping fishes from the catch net. However, this design sometimes affects the bait fish when released into the tank, damaging the bait fish by losing scale and scratching.

(2) In the live bait tank

- There are possibilities of high mortality of bait fish due to low dissolved oxygen, poor water circulation system due to the high position of water supply and drainage in the tank.
- Fishers' sometime dive into live bait tank to remove dead bait by connecting hose with scupper in the bottom of tank. But this activity impacts the bait fish in tank. It would also make it difficult to quantify the amount of dead bait in tank.
- Since the live bait tank is like an open pool, water can move in any direction due to rolling or pitching of the boat, and this water movement stresses the bait fish in tank.

Measures for the improvement of live bait survival rate

(1) Improvement of the live bait fishing operation

Live baits come up on the catch net sometimes during the bait fishing operation because of small space of water in the net, light weight material of the netting and careless handling when fishers in the water hold up the net. Use of a small stainless steel ring is an effective tool to keep the water depth in the net and prevent the bait being exposed to air. In addition, this ring weight has the added advantages of being able to easily scoop the live bait according to the type of species based on the fish behavior. Some types of fish come up to surface and others come down to deeper part.

(2) Modification of scoop net

In Japan, the bait fish are stocked in cage (tamed bait in artificial environment) for a while (~1-2 weeks) before selling to the skipjack pole and line fishing boat, and handled with care during transfer of bait to the tank, for example, using a bucket with water to transfer the fish.
On the other hand, Maldives has different manner of live bait handling. The bait fish are not stocked in cage (wild bait) and fishers load the bait fish immediately to the bait tank onboard caught using ordinary scoop net. Bait fishes are damaged in this process due to friction with the net and other fish.
During the on board operation survey, modified scoop net was introduced for gentle handling and efficient transfer. The net was designed using canvas material at the bottom and netting material above (see Fig.1). This allowed the transfer of bait with water.

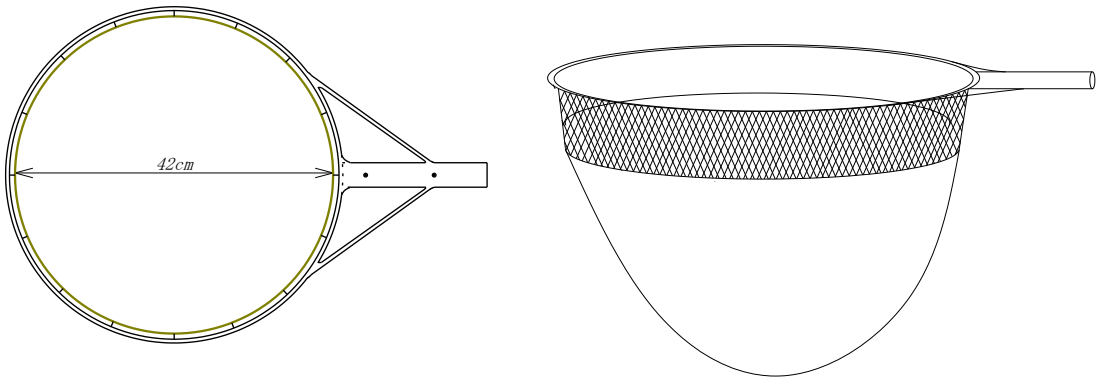


Figure-1 Modified scoop net: Netting material above and canvas material on the bottom allowing transfer of bait with water

(3) Modification plan for live baitfish tank

To address the issues, the following 3 modifications were made to the bait tank:

- moving the tank hatch higher
- Installation of new water supply pipe with small holes on the underside of the live bait tank
- Installation of a pipe to remove the dead bait with the drainage water.

1) Two main reasons to raise hatch height include minimizing the water movement in the tank to eliminate the damage caused by water movement in the tank and the second is to drain the dead bait automatically by utilizing the water pressure. Overflowed water from the tank is drained through the PVC drain pipe which is connected to the outside of boat hull.

2) For efficient water circulation within the tank, pumped up water will be supplied from the higher part of tank through PVC pipe with many holes for gentle release of water into tank. The current water circulation system is inappropriate due to water supply and drainage mouths being located in upper position.

3) Improvement of the dead bait drainage system from the bottom of tank. So far, fishermen manually drain the dead bait by diving and connecting the pipe with outlet in the tank. This method has two issues; 1) giving stress to the live bait in tank and 2) not being able to quantify the amount of dead bait. The Pilot Project will install an automatic dead bait draining system which uses syphoning mechanisms, by PVC pipes connected from the bottom of tank to deck side. The automatic drain system will function due to the water pressure of the raised hatch position.

This concept of modification is shown in figure 2.

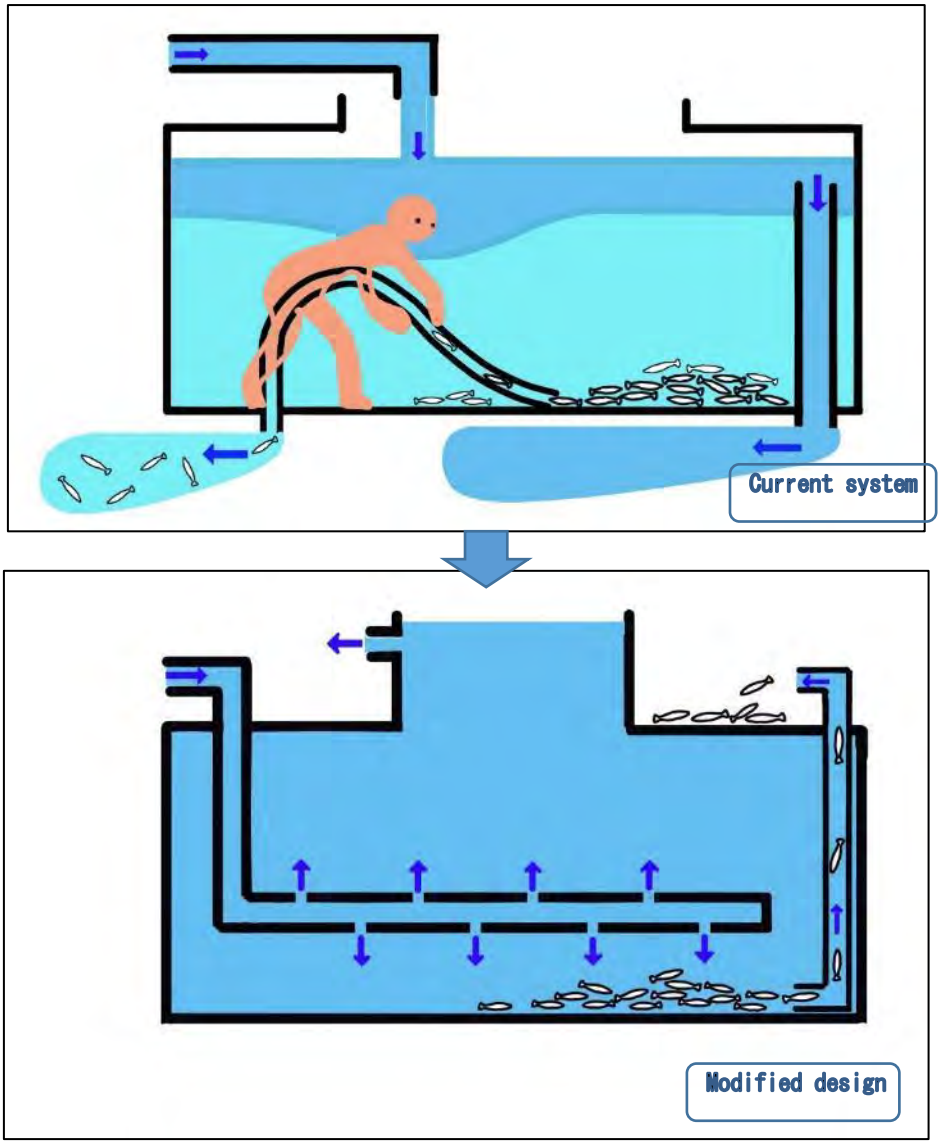


Figure 2: Concept of the current live bait tank and the modified design

4) Aeration system installation

In addition to the above mentioned modifications, aeration of the water will optimize the level of dissolved oxygen in the tank and improve the water condition within the tank.

1.2 Modification of Live Bait Tank

1. Project area: Maradhoo in Addu Atoll
2. Fishing boat : RASKURI
3. Period of work: September 2015(16days)
4. Supervisor: Morimitsu Ritsuo (JICA expert, fishing technology), Carpenter: Ali Rasheed

The boat belonging to HF on which the preliminary study was conducted was not able to progress with the project as planned previously. Hence a new boat named RASKURI was selected for the project after discussion with the owner of boat Mr. Ali Didi. Due to a series of reselection work and dispatch of the expert to the boat, there was a one month delay in implementing this activity. For improving the survival rate of live bait in the bait tanks of the test boat, two main modification works were carried out. This includes modifying the structure of the tank and modifications for improving handling of live bait.

Live bait tank modification work

The live bait tank of RASKURI was modified by carpenter Mr. Ali Rasheed of Addu Atoll. All planning and modification work was carried out under the guidance of JICA fish technology expert. The modification works of RASKURI had to undergo some difficulties such as short construction time and different piping arrangement from original structure.

One live bait tank on the boat was modified and the other tank left without any alteration as a control tank. Modification work consisted of the following 4 alterations for the purpose of stabilizing and efficient seawater circulation in live bait tank.

- Hatch height rising
- New water supply pipe installation
- Dead bait removing pipe installation
- PVC pipe installation for automatic water drainage from the lower position in tank by the utilization of water pressure.

In order for sufficient water supply to the large volume of live bait tank (approximately 27,000 liters); two new PVC pipes with slits on the lower side and with holes on the upper side were connected to two pumps separately. This water supply and drainage system is useful to generate gentle water circulation in tank to prevent stress and damage to the live bait.

Figure 2 presents cross section drawings of the bait tank before and after the modification work. Figure 3 depicts the live bait tank before and after the change.

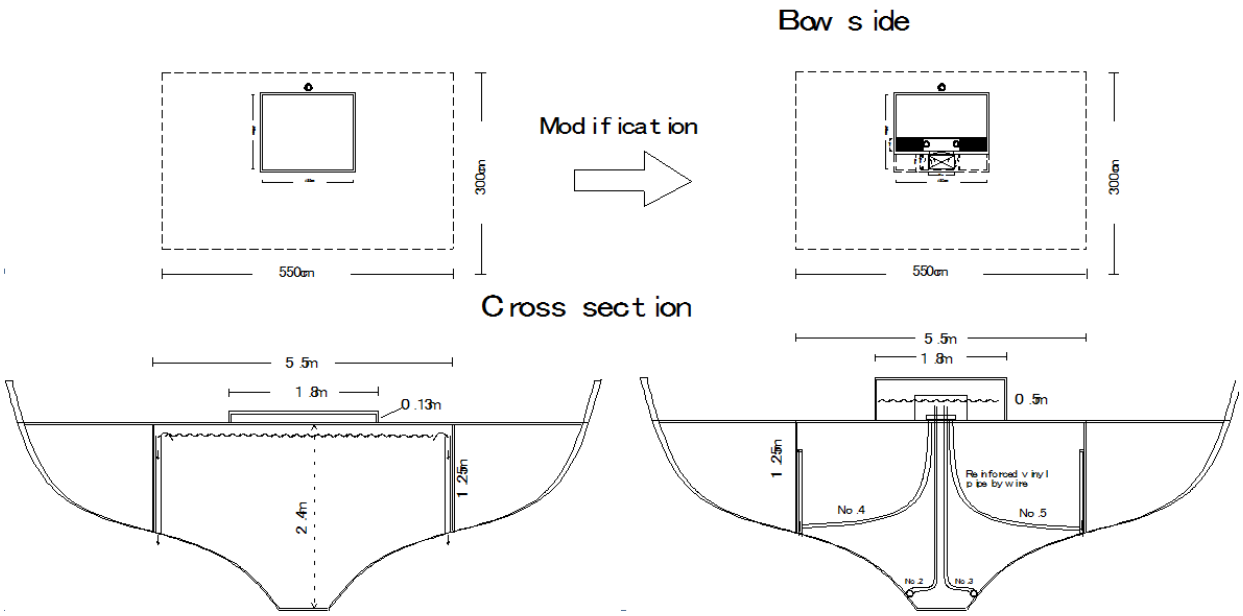


Figure 3: Live bait tank design cross sections before and after the modification work

Live bait tank (before modification)

Live bait tank (after modification)

Figure 4: RASKURI boat live bait tank before and after the modification work

Measures to improve the survival rate of bait fish

For the improvement of live bait survival rate, utilization of modified live bait tank and several other suggestions were provided that would improve bait fishing operation.

(1) Bait fishing operation

Originally rectangle type of PVC weight is set in the cod part of netting and bait collection net in tank for the prevention of bait fish from coming out or exposure to air. For the more suitable handling of bait fish, MASPLAN recommended two types of stainless steel ring weight to preserve appropriate space in net and usage of scoop net that can carry bait fish with water at once. But it was confirmed that the many jellyfish caught with live bait sometimes, in case of that the bait fish should be transferred immediately by common scoop net to the live bait tank for reduction of damage. By the above mentions improvement points, the guidance for careful handling and immediate transfer were mainly focused.

(2) Improvement by live bait tank modification

Water quality in the tank can be maintained by effectiveness of water circulation system such as water supply in tank, drainage of overflowed water from raised hatch and removal of water from the bottom of the tank by the syphon effect using water pressure in tank. In addition the installation of dead bait drainage pipe aimed to reduce the stress to bait fish in the tank as number of dives had to be made into the tank by fisher for removing dead bait. Moreover, water cleaning by draining water from the bottom of the tank, easily measure dead bait and raised hatch can minimize water movement even during rough sea condition are also advantages of this new system.

For the future task, making a slope in the bottom of the bait tank for collecting dead bait automatically remained due to the lack of time. Therefore it is advisable to undertake the changes to the tank for dead bait drainage system in the near future.

(3) New scoop net introduction for bait fish

A new scoop net was introduced for reducing injuries to bait fish at the time of transferring bait from the net to the tank. (See Figure 5). Though the shape of this net is same as ordinary type of scoop net, the bottom is consisted of water proof material for gentle transfer with water from net to live bait tank in the boat. Four modified scoop nets were prepared in Japan then conveyed to Maldives for conducting a survey and trial by the PP fishing boat of RASKURI. At the same time MASPLAN makes plan to get information on the use of modified scoop net from the fishing boat of Khazaanaa on which a previous survey was conducted. After this trial operation, the angle between frame and handle of scoop net were changed to the Maldivian style by the suggestion of fishers.

Figure 5: Modified scoop net with netting in the upper part and water proof material in below.

(4) One way water supply pipe with valve

Many fishing boats have the water intake pipe setup in the scupper hole in bottom of the hull; it could not keep water position at a high level in the live bait tank. In such a case, some pole and line fishing boats had to pump up water for keeping appropriate level of water in the tank. To cope with this current situation, one way water supply pipe with valve was tried experimentally aiming to reduce the fuel consumption and extension of pump life. As a result of this trial, intake water quantities become lower along with increasing water level in tank. Consequently, the necessary steps for the improvement of this pipe requires continually.

1.3 Additional Modification Work (Deadbait Automatic Drainage System)

Project area: Maradhoo in Addu Atoll
Fishing boat：RASKURI
Period: 11th September 2016 to 17 September 2016（7days）
Supervisor: Morimitsu Ritsuo (JICA expert, fishing technology), Carpenter: Ali Rasheed

Additional developments to the modified tank were brought about to reduce the baitfish mortality rate further. This includes installing the automatic dead bait drainage system and improving the water circulation in the tank. So far, dead bait collected at the bottom of the tank was manually drained by diving in and connecting the pipe with outlet in the tank. This method has two issues; that is creating stress to the live bait in tank and not being able to accurately quantify the amount of dead bait.

The automatic system functions by accumulating all dead bait in one place by making a slope in the bottom of tank and then draining the dead bait using water pressure (syphon age) through PVC pipes connected from the bottom of the tank to the deck side. The modification of the design is presented in Figure 6. Position of hatch in the tank was raised creating increased water pressure that facilitates water from the bottom of the

tank to syphon age. Also longer slits were made on the PVC pipe located in the bottom of tank. Bait tank modification work is depicted in Figure7.

By those functional improvements, water circulation system in the tank has been changed efficiently by supplying water from up and draining water from bottom. Moreover, this water circulation system can contribute to cleaning of water in the tank. It is known that the live bait easily die from dirty water caused by dead bait. For the prevention of that, environment in the tank has been improved remarkably. On the other hand, live bait sometimes comes in to dead bait gathering space under the sorting device (Strainer). In case of that, it is recommendable that the rid of dead bait drainage pipe be kept covered for a while till loaded live bait stay stably in the tank for prevention of live bait escape.

During trial operation, dead baits gathered by newly fixed slopes were drained as planned from the bottom of the tank with water. In addition to that, water drainage volume was increased by slit expansions on PVC located in the bottom of tank and by reducing the on deck pipe height.

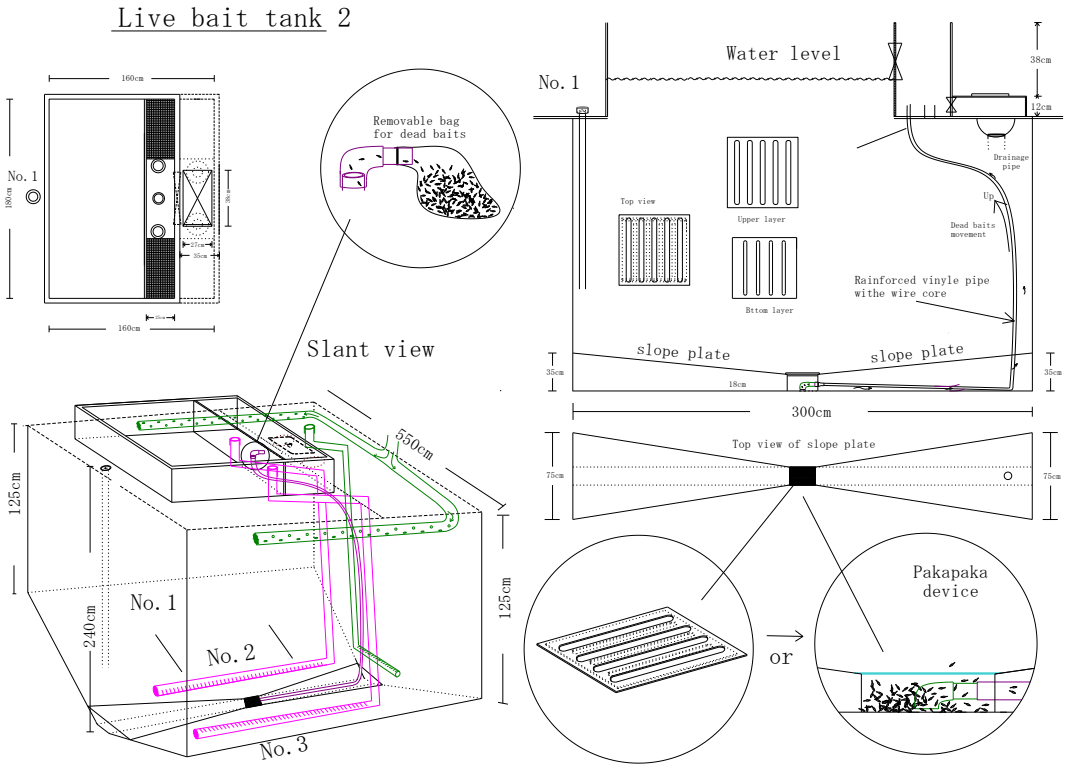


Figure 6: New modified design of the tank

Bottom of the tank before modified

Making drainage pipe from the stern

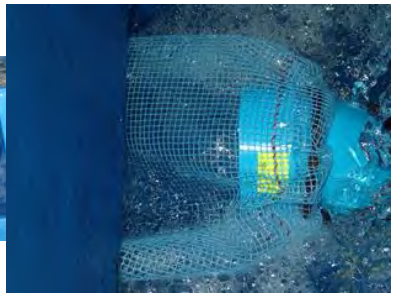
Slope making from both sides

Removable pipe for dead bait drainage

Sorting device (strainer)

Completion of slope in the bottom of tank

All drainage water come together in one place



Dead bait drainage pipe covered by collection net

Water intake pipe

Supply of water into live bait tank

Dead bait sorting device (strainer) in the tank

Remainder in the bottom of tank

Figure 7 : Bait tank modification work

2 Monitoring and Survey Data Collection

2.1 Monitoring Observations

Project area: Mainly Maradhoo in Addu Atoll
Fishing boat：RASKURI
Period of Monitoring: One year (from January 2016 to December 2016)
Total no of Observations: 10
Team:

Supervisor/Administrator, Dr Shazla Mohamed, The Maldives National University
Research Assistant, Mr Ibrahim Fikry, The Maldives National University
Observer, Mr Ibrahim Yamyn, The Maldives National University
JICA expert, Fishing Technical, Mr. Morimitsu Ritsuo
JICA expert, Fisheries Resource Management, Dr. Echigo Manabu

Observation trips were conducted from December 2015 to January 2017. Observation dates and other relevant information regarding the observation trips are summarized in Table 2.

Table 2: Observation Schedule Details

#	Date	Observed by	Notes
1	4th Dec 2015	Morimitsui Ritsuo Ibrahim Yamyn	Trial and training of Observers
2	6th Dec 2015	Morimitsui Ritsuo Ibrahim Yamyn	Trial and training of Observers
3	2nd Jan 2016	Ibrahim Yamyn	Data collection successful
4	3rd Jan 2016	Ibrahim Yamyn	Data collection successful
5	1st Feb 2016	Ibrahim Yamyn	Data collection successful
6	27th Feb 2016	Ibrahim Yamyn	Data collection successful
7	17th Apr 2016	Ibrahim Yamyn	Data collection successful
8	19th Apr 2016	Ibrahim Yamyn	Data collection successful
9	16-17th Sep 2016	Morimitsu Ritsuo	Not successful
10	22nd Sep 2016	Ibrahim Yamyn	Data collection successful Data collection delayed due to absence of observer in late May 2016 (Semester break/Ramazaan), and RASKURI boat being

			docked for maintenance work in early June 2016. Due to the low fish catch in Southern Atolls, RASKURI operated in Northern Atolls from July onwards; this limits the accessibility to the boat to conduct observations.
11	29th Sep 2016	Ibrahim Yamyn	Data collection successful
12	19-25th Nov 2016	Morimitsu Ritsuo	Not successful due to strong tidal waves and small amount of bait fish caught which were not adequate to distribute to two tanks and hence was not able to compare.
13	13-15th Jan 2017	Ibrahim fikry	Data collection successful
14	16-18th Jan 2017	Ibrahim fikry	Data collection successful
15	24-29th Jan 2017	Morimitsu Ritsuo	Not successful due to high load of bait in the modified tank and determination of dead bait not possible

Due to the low fish catch in Addu and Southern Atolls, Raskuri boat operated in Northern Atolls from July to September limiting the accessibility of the boat to conduct observations during this period since they are not stationed in any particular location. Arrangement was made for boat to pick observer when they came near Male'. Rough sea, low catch, and availability of RASKURI boat and availability of the observer were factors that lead to irregularity of the observation trips.

The following points were observed and recorded on the checklist during each trip with reference to improved handling:

- Use of ring weight for keeping water depth in the net
- Use of modified scoop for transferring live bait from the net to the tank
- Careful handling of live bait during operation of catch
- Live bait condition after loading to the tank by visual check
- Extent of damage to live bait during transfer from net to tank by visual check
- Number of minutes taken to load bait from net to tank
- How much bait were exposed to air during the operation by visual check
- Condition of the water circulation system for regular functioning

Bait fish mortality of two live bait tanks, the modified tank and the control tank (unmodified) were compared during the observations and recorded on the monitoring record sheet. The following information from each tank (both modified and control tank) were checked and recorded on during each observation trip:

- Time of loading bait fish to bait tank
- species and weight (estimation of weight by scoop net)
- Water temperature at time of loading
- Time at end of fishing operation (using a thermometer)
- Weight of dead bait fish by species
- Water temperature of tanks at the end of day's operation

2.1.1 Estimation of total amount of bait

To determine the total amount of bait fish transferred to each tank:

1. a plastic basket was weighed using a spring scale (Figure 8)
2. one scoop of baitfish was transferred to the basket filled with water and lifted up by spring scale for reading off the scale.
3. 2~3times of weighing were carried out for the estimation of one scoop of baitfish.
4. the weight of one scoop of bait was obtained by deducting the initial weight of basket
5. the composition of each species of bait was estimated during the baitfish measurement.

An approximate amount of bait loaded to each tank was determined by multiplying the weight of one scoop of bait with the number of scoops of bait transferred to the tank as shown below. This measuring method was repeated for each observation trip and the information recorded on the monitoring record sheet.

Total amount of bait (in kg) = weight of one scoop of bait (in kg) x number of scoops transferred to the tank

2.1.2 Estimation of dead bait

Dead bait was collected from each tank at 2 hour time intervals for a period of 10 hours unless the operation ends before this time. Dead bait collected at each time interval was transferred to a container and weighed by scale. The total amount of dead bait collected during each interval were calculated by deducting the weight of the container and recorded.

2.1.3 Determination of bait fish survival rate

Survival rate of bait fish in each tank that is modified and control tanks was calculated using the following formula for each observation.

$$\text{Survival rate} = \frac{\text{(Total weight of the bait in the tank – Dead bait in the given time interval)}}{\text{Total weight of the bait in the tank}} \times 100$$

Water temperature of both tanks were checked before and after loading the live bait and recorded. Data from the monitoring sheets were input in Excel, then analyzed and graphical outputs produced.

Observer weighing the empty basket

Use of modified scoop to transfer bait to the tank from the net

Counting the number of scoops transferred in to the tank

Dead bait collected in a container for weighing

Figure 8: Collection of monitoring information by the observer

2.2 Qualitative Information on Opinions of Fishers

Qualitative information regarding the effectiveness of the method and overall opinion on the modifications was obtained through a survey conducted among the fishers onboard the study vessel Raskuri. An open ended survey questionnaire with a rating for overall impression of the use of modified tank was designed and administered to a total of 15 fishers including the captain of the vessel. The questionnaire is given in Appendix 3. Information from the survey was input into MS Excel. The method utilized for data analysis was content analysis which includes identifying major categories for the responses given by the fishers. Categories were generated inductively from the information given.

3 Findings of Bait Fish Monitoring and Survey Onboard

3.1 Bait fish monitoring

Live bait survival was observed from two tanks (modified and control tank) build in the fishing vessel for a period of one year. Total 10 observation trips were successfully conducted. Figure 9 represents the bait fish survival rate in percentage against time of observation in hours for 10 observations.

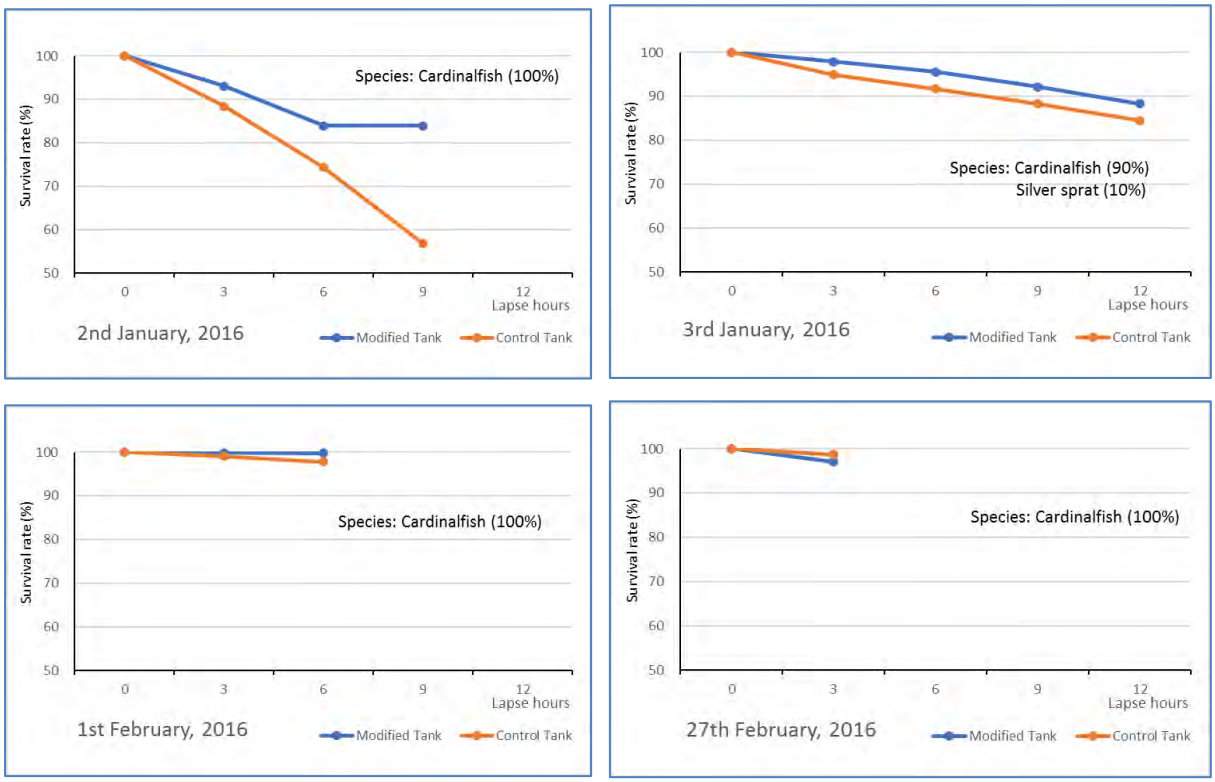


Figure 9 (1): Comparison of the bait fish survival rates of the modified and control tanks of 10 observations trips to Raskuri boat (continued)

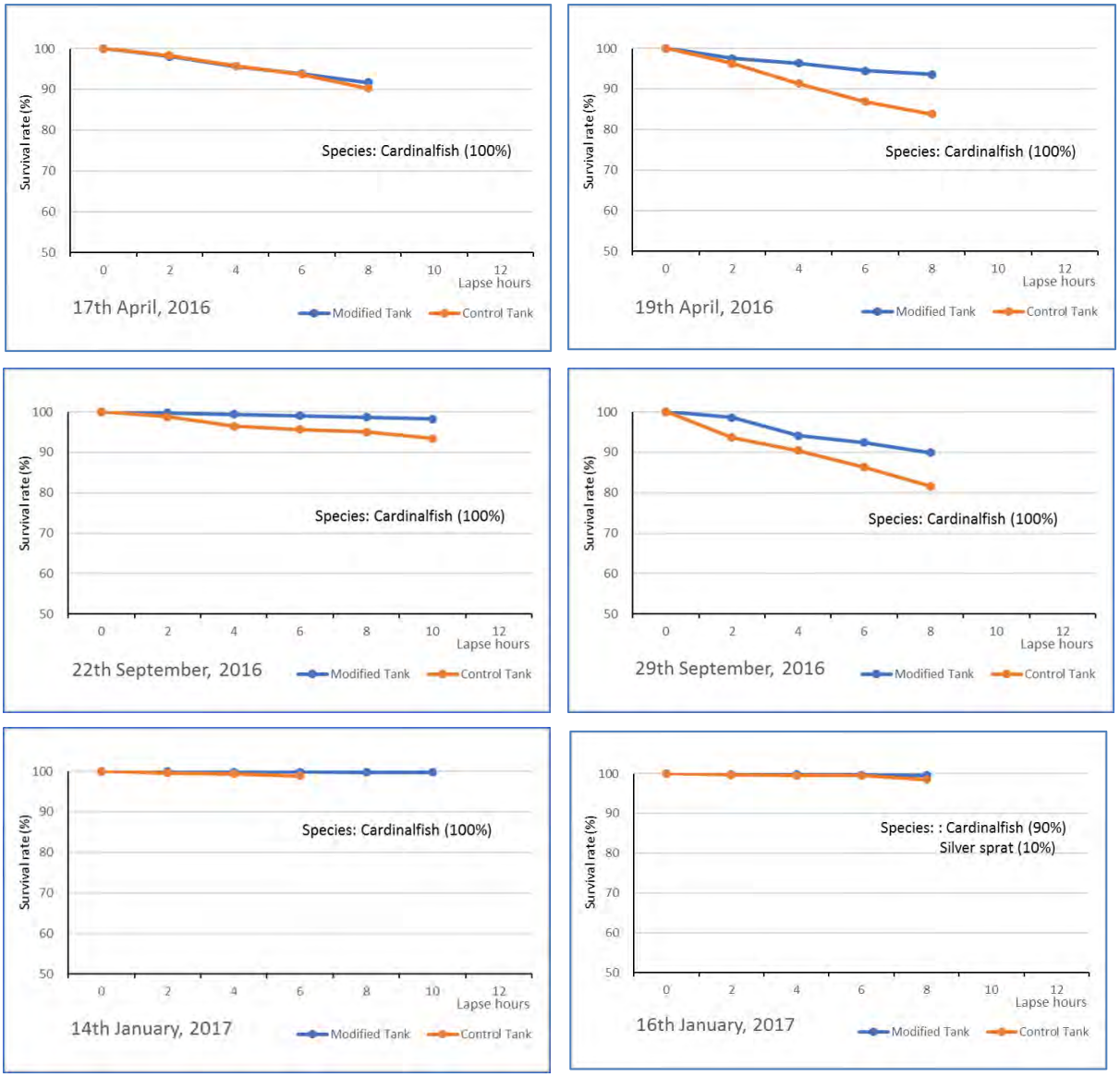


Figure 9 (2): Comparison of the bait fish survival rates of the modified and control tanks of 10 observations trips to Raskuri boat

The first observation trip was completed on 2nd January 2016. Bait composition in both modified and control tanks were 100 percent Cardinalfish. Fishing operation lasted for 9 hours. In the first 6 hours, survival rate of bait fish in the modified tank decreased to 83.9% and stays constant for the next three hours. In contrast, the bait fish survival rate in the control tank gradually fell until it reached 56.8% after 9 hours.

For observation data collected on 3rd January 2016, bait fish composition is 90% Cardinal fish and 10% Silver sprat. Bait fish survival rate decrease constantly over time for both tanks with only 4% difference between the survival rates at the end of the 12 hour fishing operation. The rates at the end were 88.3% and 84.5% for modified and control tanks, respectively.

For observation data collected on 1st February 2016, bait composition in the tanks were 100% Cardinal fish and the fishing operation lasted for 6 hours. In modified tank, bait fish survival rate was found to 99.7% whereas in the control tank survival rate was 97.7% at the end of the 6 hour period.

Fishing operation lasted for only 3 hours on the observation trip conducted on 27th February 2016. Bait composition in the tanks were 100% Cardinal fish. At the end of this time, bait survival rate was 98.6% in the control tank 97.1% in the modified tank.

For observation data collected on 17th April 2016, bait composition in the tanks were 100% Cardinal fish and the fishing operation lasted for 8 hours. Survival rate gradually decreased over time for both tanks. Bait survival rate was 91.8 % for modified tank and 90.3% for control tank, with a minor difference of 1.4% at the end of the fishing operation.

Bait composition in the tanks were 100% Cardinalfish for observation conducted on 19th April 2016. The fishing operation continued for 8 hours. Survival rate decreased in both tanks over time. Low survival rate was observed in control tank. In 8th hour of fishing operation, survival rate falls to 83.3% in control tank, but in the modified tank survival rate was 93.6% indicating around a 10% difference.

As frequently observed, bait composition in the tanks were 100% Cardinalfish for data collected on 22nd September 2016. The fishing operation lasted for 10 hours. A gradual decrease was evident for both tanks although the bait survival rate was slightly higher for the modified tank compared to the control tank. At the end of the 10 hours fishing operation, survival rates showed a 4.8% difference with 98.2% for modified and 93.41 for the control tank. This data was collected after the second modification to introduce the dead bait automatic drainage system was completed.

For data collected on 29th September 2016, bait composition in the tanks were 100% Cardinal fish. Survival rate of the bait fish decreased over time for both tanks. Over a period 8 hours of fishing operation, survival rate was decreased to 81.6% in control tank, but the rate in the modified tank mortality was 89.9% which is 8.29% higher than the control tank.

According to data collected on 14th January 2017, bait composition in the tanks were 100% Cardinalfish and the fishing operation continued for 10 hours. At the 6th hour of the operation, survival rate of bait fish in the modified tank was found to be 99.8% while a similar slightly decreased rate (98.9%) was observed for the control tank. It should be noted that a high survival rate of the bait fish was maintained for the modified tank throughout the fishing operation which was 99.7% at the end of the 10 hour period. The total catch transferred to the modified tank during this trip was high (504 kg) while less than half this amount (186 kg) was stored in the control tank.

Bait fish composition in the tanks were 90% Cardinalfish and 10% Silver Sprat for the observation trip conducted on 16th January 2017. At the end of the 8 hour fishing operation, survival rate of bait fish in the modified tank was 99.6% and the control tank was 98.5%.

3.2 Opinion of Fishers

Information obtained from the survey questionnaire administered to 15 fishers onboard the test vessel is reported. The score for the overall opinion of the fishers with regards to activities related to bait tank modification is given in table 3. All fishers strongly agree or agree that the modified bait tank is easier to handle than before the modification. Most of them also strongly agree (11) or agree that the scoop net and stainless steel ring weight is easy and convenient to handle. With regards to monitoring method and coordination, most fishers strongly agree or agree that it is adequate. Working manner of both the observer and the expert was considered to be acceptable.

Table 3: Overall opinion of fishers onboard study vessel Raskuri regarding the effectiveness of modification to bait tank and handling methods

question	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree	Total
Is it easy to handle the modified live baitfish tank?	10	5	0	0	0	15
Is it easy to handle the scoop net with water?	11	2	2	0	0	15
Is it convenient to use the stainless steel ring weight?	11	1	3	0	0	15

When asked to express their opinion about the modified bait tank, 13 out of 15 fishers gave a positive response quoting phrases such as “highly recommended” or working well” or “worth the investment”. Some have pointed out that it is easier to handle and the automatic dead bait removal system was and added advantage. Two of the fishers expressed their concerns regarding the small size of the opening (hatch) in the tank and recommended to modify the opening.

All 15 fishers from Raskuri agreed that they have acquired new information or knowledge from this project. Most of them (7) agree that the whole system was new to them while others indicated that they have learned about the water pipe arrangement and drainage system as well as the automatic bait removal system. One of the fishers said that he would now be able carry out the live bait tank modification work. Other points highlighted include knowledge that the traditional tank has inadequate water circulation, high bait mortality due to lack of aeration in the unaltered tank design, and suitability of modified tank when the current is high. Also they have learnt that the new scoop net minimizes damage to the bait.

Fishers were also inquired to indicate further modifications that would be necessary for improvement of live bait survival rate in the future. The recommendations include making the opening of the tank bigger for improved handling of bait, increase aeration in the tank by introducing more pumps or higher capacity pumps, and larger bait tanks. In addition, use of bigger drainage pipe to prevent blockage of the outlet by dead fish and use of water-proof lights was suggested.

Finally, fishers were asked to indicate in which tank they think baitfish can survive longer after 3 days of storage. All fifteen of then agreed that the modified tank will be more effective in reducing mortality of bait fish after elongated storage (after 3 days).

4 Discussion and Conclusions

This study is focused on improving the survival of live bait used in skipjack tuna fishery especially in pole-and-line fishery. Based on the data from the observation trips, bait fish mortality is found to be generally low in the modified tank when compared to the traditional control tank. This is true except for one trip where the fishing operation continued for 3 hours only and hence this could be considered as an outlier. However, the difference between the survival rate in the modified tank and control tank varied widely between the observations ranging from 0.97% to 27.1%. The huge deviation could be attributed to an underestimation of the amount of dead bait measured from the control tank. Collection of dead bait from the control tank was a challenge since the observer had to dive in and manually collect the dead fish from the bottom of the tank. In addition, due to the design of the tank, a substantial amount of dead bait was lost through the drainage system and is unaccounted for. On the other hand, the design and especially the automatic dead bait removal system facilitated accurate estimation of dead bait in the modified tank.

There are number of other factors contributing to the increased survival rate of bait fish in the modified tank. It was observed that in control tank bait fish are under stress condition due to the design of the tank. This condition generally arises during rough sea conditions where the vessel rolls resulting in sudden movement of water in the bait tank. Rising hatch position in the modified tank fills the entire tank and reduces sudden movement of water in the tank under similar conditions. Modified tank is also designed with an efficient water circulation system creating a favorable well aerated environment for the bait fish. In the control tank, water circulation is restricted due to inbuilt design of the tank providing limited aeration for the bait fish in the tank. An added advantage is that it is easy to observe the live bait condition and the amount remaining from the modified tank since the water surface is very smooth. Also water quality in the modified tank is improved since dead bait is drained out automatically creating favorable environment for the fish.

Through the experience of using modified bait tank over a period of time, fishers onboard Raskuri realized the importance of a good water circulation system for increased survival of the bait fish. The improved water circulation system of the modified tank was found to allow bait fish to move freely in circulation motion under less stress conditions and hold more bait for a longer period resulting in high survival rate. With these findings priority was given to transfer bait fish to the modified tank and not the control tank. Fishers prefer to use the modified tank first and only consider control tank in most instances when the maximum capacity of the modified tank has reached. This is evident from the data collected during observations. For example, for

observation trip on 14th Jan 2017, a total of 504 kg of bait were held in the modified while only 186 kg of bait were placed in the control tank. During this observation bait was found to survive for more than 10 hours in the modified tank with a survival rate of 99.7 percent. The high load on the modified tank concentrates the amount of bait could create stress and high mortality.

The new design of the modified tank due to the raised hatch has advantage during cleaning of dead bait from the bottom of the tank. Raised hatch give additional pressure to the bottom of the tank which push the dead bait to the top via drainage pipe. In addition, introduction of the automatic dead bait removal system avoids frequent dive in to the tank for cleaning or collection of dead bait or waste deposited in the bottom of the tank. This also results in reduction of labor load. For the control tank, dead bait and other waste deposits are collected manually. Manual cleaning of the control tank and frequent dive results in increased stress and high mortality of the bait fish. To support this, all fishers strongly agree or agree that the modified tank is easier to handle than the conventional tanks.

Two types of bait fish that is short-toothed cardinal fish (*Apogon apogonides*, Bleeker, 1856) and other cardinal fish and Silver sprat (*Spratelliodes gracilis*) were dominant during the study. Cardinal fish was the main species of bait caught during all observations. In addition, 10% of bait fish were silver sprat during two out of 10 observations. According to Fishers, silver sprat is a weak and difficult to handle resulting in high mortality in control conditions. Silver sprat was the dominating species in the dead bait composition for the two observations where this species was present.

According to Fishers, overall handling of the bait was improved by the introduction of modified water scoop net and stainless steel ring for maintaining the shape of the net. The new scoop net design prevents overcrowding and minimizes exposure of bait fish to air since bait is transferred with water. Similarly the stainless steel ring maintained water depth in the bait net till the very last scoop of bait was transferred to tanks. Hence, these factors, that is use of well-designed equipment and improved handling of bait fish overall has contributed to decreased mortality of bait fish. In addition, most fishers agree that the scoop net and stainless steel ring is easy and convenient to handle. Introduction of the underwater light was found to be effective at night time with bait fish aggregating and surrounding the light in the tanks.

Although there is some inaccuracy of data from the observations, opinion of Fishers working on board was very positive regarding the use of modified tank. They highly recommend the use of modified bait tanks especially for new boats. They also agree that the cost incurred for the modification work is worth the investment. All Fishers came to a consensus regarding the improved effectiveness of modified tank in reducing mortality of bait fish after elongated storage (after 3 days) when compared to the control tank. They also recommended some further improvements to the design which includes: making the opening of the tank bigger for improved handling of bait; increased aeration in the tank by introducing higher capacity pumps or other efficient aeration system; and increasing the size of bait tanks. In addition, use of bigger drainage pipe to prevent blockage of the outlet by dead fish and use of water-proof lights was suggested.

During the phase of the project and especially the monitoring observations, there had been several issues which resulted in delays and inconsistent results. It was sometimes difficult to schedule trips for observations since the timing and fishing grounds depend on the fishing condition. There had been issues in comparing survival rates of bait fish in two tanks due to low catch of bait fish that was inadequate for such a study. This was mainly due to weather conditions such as tidal current and moonlight. Weather conditions such as rough sea may affect the survival rates of bait fish even if they are the same species. Hence, this could contribute to differences in data between the observation trips. Technical issues include difficulty in collecting bait from the control tank especially during rough seas and loss of bait through overflow pipe of the control tank.

In summary, modification of the bait tank can be considered to have resulted in efficient circulation and reduced mortality of bait fish. Mortality was generally low in the modified tank compared to the control tank although there was a wide variation in survival rates of bait in modified and control tanks between the observations. This finding is supported by opinion and behavior of fishers who agreed that the modified tank was more effective in reducing fish mortality and recommended them especially for new boats. The modified tank was also found to be easy to clean and handle specifically the automatic dead bait removal system was well received. Effective onboard handling and modification of fishing gear such as the modified scoop net and stainless steel ring was considered as positive improvements. Further modifications to the design were also proposed by the Fishers.

5 Recommendations

The boat used for study purpose was a privately owned vessel engaged in routine fishing operations and hence flexibility was limited in carrying out work according to the plan. For example, collection of dead bait from the tank could have been more accurate if the boat was stationary that is if fishing operation was halted to concentrate only on data collection. Hence, it is recommended to hire a boat for any future studies planned so that certain conditions can be controlled and variations limited.

Similarly, there had been instances where there were huge differences between the amounts of bait transferred to modified and control tanks. Such deviations should be kept to the minimum and similar amount and density of bait transferred to both tanks for producing accurate results in future studies. This again could be controlled if a vessel was hired.

Dead bait collection method utilized in this study for estimating the amount of dead from control tank was not accurate. Hence, an alternative or improved method should be used for the purpose to yield better quality results. Also, overflow of water from the control tank which resulted in loss of dead bait contributed to errors in the dead bait count. It is recommended to cover the overflow outlet with net to prevent drainage of dead bait with the water.

In the current studies, different species of bait were also loaded to the same tank. For accurate comparison, it is recommended that same species of bait be loaded to both tanks at a time and avoid mixing of different species since the vulnerability and mortality rates are different. Hence, it is important maintain this parameter constant.

Bait tank in this study was modified as per Japanese model but since the design and methods utilized in Maldives are completely different, a design that incorporates the requirements of Maldives Fishers would be better suited to be adopted. Unlike in Japan where boats have many small bait tanks, Maldivian boats use lesser but larger tanks. Hence, there was a recommendation from Fishers onboard study vessel to make the opening hatch of the modified tank bigger for improved handling and for use of larger tanks. Additional modification suggested by them include increasing aeration in the tank by introducing higher capacity pumps or other efficient aeration system, use of bigger drainage pipe to prevent blockage of the outlet by dead fish and use of water-proof lights. These suggestions have to be technically verified to check if this improves the conditions before implementation.

Finally, the study results suggested potential extension of this new technology to other vessels involved in skipjack tuna pole and line fishery across of the country. This is in view that modified design of the bait tank and improved handling including use of modified water scoop has resulted in increased survival of bait fish as evident from both observation data and opinion of Fishers. It is important that information regarding modification method and cost be disseminated to those involved in fishing operations across the country.

Appendix 1: MASPLAN Live Bait Mortality Monitoring Recording Sheet

	Catch			After Fishing					
Tank A (former type)	Date / / 2015		Time : AM / PM	Dead bait weight					
	Water temperature		℃						
	Total Catch		Number of scoop times	Time	: AM/PM	: AM/PM	: AM/PM	: AM/PM	: AM/PM
			Total weight kg	Weight	kg	kg	kg	kg	kg
	Component ratio	Silver sprat	%	Silver sprat	%	%	%	%	%
		Blue sprat	%	Blue sprat	%	%	%	%	%
		Anchovy	%	Anchovy	%	%	%	%	%
		Fusiliers	%	Fusiliers	%	%	%	%	%
		Cardinalfishes	%	Cardinalfishes	%	%	%	%	%
		Others	%	Others	%	%	%	%	%
Tank B (modified type)	Date / / 2015		Time : AM / PM	Dead bait weight					
	Water temperature		℃						
	Total Catch		Number of scoop times	Time	: AM/PM	: AM/PM	: AM/PM	: AM/PM	: AM/PM
			Total weight kg	Weight	kg	kg	kg	kg	kg
	Component ratio	Silver sprat	%	Silver sprat	%	%	%	%	%
		Blue sprat	%	Blue sprat	%	%	%	%	%
		Anchovy	%	Anchovy	%	%	%	%	%
		Fusiliers	%	Fusiliers	%	%	%	%	%
		Cardinalfishes	%	Cardinalfishes	%	%	%	%	%
		Others	%	Others	%	%	%	%	%

Recorder: _____ **Log keeper's signature:** _____

Appendix 2 Live Bait Monitoring Checklist

At the time of live bait catches and loading to tank in the boat

Did they utilize the ring-weight or other weight for keeping a water depth in the net?		Yes		No			
Did they utilize modified scoop net for transferring the live bait from the net to the tank?		Yes		No			
How was the live bait handled during operation of catch?		Carefully		Carelessly			
How was the live bait condition after loading to the tank? (please check visually)		Good		Moderate		Bad	
How much was the damage of live bait at the time of transferring from the net to the tank? (Please check visually)		Little		Moderate		Much	
How many minutes fisher spend to load the bait from the net to the tank?		1	2	3	4	5	
How much bait were exposed to air during the operation? (please check visually)		No		few		Much	
The condition of water circulation system (please check the drain water entrance located on the top side of hatch)		Regular		Abnormal			

Recorder: **Log keeper's signature:**

Appendix3 Opinion of Fishers Survey Questionnaire

Questionnaire for the improvement of live baitfish survival rate (PP-1)

Opinion of Fishers onboard RASKURI

1 What is you impression of the entire project.

		Very good	Good	Ordinarily	bad	very bad	Total
①	Is it easy to use the modified live baitfish tank ?						
②	Is it easy to handle the scoop net with water ?						
③	Is it convenient to use the stainless steel ring weight ?						

2 Please describe your impression of the modified live baitfish tank ?

3 Did you get any new information or knowledge from this project ?

Yes	No

In case of [Yes], please describe it.

4 Is it possible to accept the modified live baitfish tank system on other boats, do you think ?

Yes	No

[Reference]: total expenditure for the modification works of RASKURI was 72,000MRf

5 What is necessary for the improvement of live baitfish survival rate in the future, do you think?

6 Please write your additional opinion etc. if you have anything.

7 Which tank can baitfish survive longer in case of 3 days after, do you think?

	Modified tank	Original tank
Please check it		

Appendix 4 Observation Raw Data for Live Bait Mortality Monitoring

Date 2 Jan 2016

Fish species Cardinalfish (90%), Silver sprat (10%)

Dead bait weight (kg)	Total Catch (kg)	Lapse hours					
		0	3	6	9	12	
Modified Tank	4.6	0.00	0.32	0.42	0.00		
Control Tank	5.7	0.00	0.66	0.80	1.00		

Accumulation weight (kg)	Total dead bait (kg)				
Modified Tank	0.7	0.0	0.3	0.7	0.7
Control Tank	2.5	0.0	0.7	1.5	2.5

Survival rate (%)	Fainal servival rate (%)				
Modified Tank	83.91	100.00	93.04	83.91	83.91
Control Tank	56.84	100.00	88.42	74.39	56.84

Date 3 Jan 2016

Fish species Cardinalfish (90%), Silver sprat (10%)

Dead bait weight (kg)	Total Catch (kg)	Lapse hours					
		0	3	6	9	12	
Modified Tank	6.25	0.00	0.13	0.15	0.21	0.24	
Control Tank	6.5	0.00	0.33	0.21	0.22	0.25	

Accumulation weight (kg)	Total dead bait (kg)					
Modified Tank	0.7	0.0	0.1	0.3	0.5	0.7
Control Tank	1.0	0.0	0.3	0.5	0.8	1.0

Survival rate (%)	Fainal servival rate (%)					
Modified Tank	88.32	100.00	97.92	95.52	92.16	88.32
Control Tank	84.46	100.00	94.92	91.69	88.31	84.46

Date 1 Feb 2016
Fish species Cardinalfish (100%)

Dead bait weight (kg)	Total Catch (kg)	Lapse hours					
		0	3	6	9	12	
Modified Tank	175	0.00	0.18	0.23			
Control Tank	158	0.00	1.50	2.00			

Accumulation weight (kg)	Total dead bait (kg)			
Modified Tank	0.4	0.0	0.2	0.4
Control Tank	3.5	0.0	1.5	3.5

Survival rate (%)	Final survival rate (%)			
Modified Tank	99.77	100.00	99.90	99.77
Control Tank	97.78	100.00	99.05	97.78

Date 27 Feb 2016
Fish species Cardinalfish (100%)

Dead bait weight (kg)	Total Catch (kg)	Lapse hours					
		0	3	6	9	12	
Modified Tank	420	0.0	12.4				
Control Tank	150	0.0	2.0				

Accumulation weight (kg)	Total dead bait (kg)		
Modified Tank	12.4	0.0	12.4
Control Tank	2.0	0.0	2.0

Survival rate (%)	Final survival rate (%)		
Modified Tank	97.05	100.00	97.05
Control Tank	98.67	100.00	98.67

Date 17 Apr 2016
Fish species Cardinalfish (100%)

Dead bait weight (kg)	Total Catch (kg)	Lapse hours						
		0	2	4	6	8	10	12
Modified Tank	285	0.0	5.5	7.0	5.0	6.0		
Control Tank	235	0.0	4.0	6.0	4.8	8.0		

Accumulation weight (kg)	Total dead bait (kg)					
Modified Tank	23.5	0.0	5.5	12.5	17.5	23.5
Control Tank	22.8	0.0	4.0	10.0	14.8	22.8

Survival rate (%)	Final survival rate (%)					
Modified Tank	91.75	100.00	98.07	95.61	93.86	91.75
Control Tank	90.32	100.00	98.30	95.74	93.72	90.32

Date 19 Apr 2016
Fish species Cardinalfish (100%)

Dead bait weight (kg)	Total Catch (kg)	Lapse hours						
		0	2	4	6	8	10	12
Modified Tank	328	0.0	8.0	4.0	6.0	3.0		
Control Tank	162	0.0	6.0	8.0	7.3	5.0		

Accumulation weight (kg)	Total dead bait (kg)					
Modified Tank	21.0	0.0	8.0	12.0	18.0	21.0
Control Tank	26.3	0.0	6.0	14.0	21.3	26.3

Survival rate (%)	Final survival rate (%)					
Modified Tank	93.60	100.00	97.56	96.34	94.51	93.60
Control Tank	83.80	100.00	96.30	91.36	86.88	83.80

Date 22 Sep 2016
Fish species Cardinalfish (100%)

Dead bait weight (kg)	Total Catch (kg)	Lapse hours						
		0	2	4	6	8	10	12
Modified Tank	195	0.0	0.4	0.7	0.8	0.6	1.0	
Control Tank	252	0.0	3.0	6.0	2.0	1.6	4.0	

Accumulation weight (kg)	Total dead bait (kg)						
Modified Tank	3.5	0.0	0.4	1.1	1.9	2.5	3.5
Control Tank	16.6	0.0	3.0	9.0	11.0	12.6	16.6

Survival rate (%)	Final survival rate (%)						
Modified Tank	98.21	100.00	99.79	99.44	99.03	98.72	98.21
Control Tank	93.41	100.00	98.81	96.43	95.63	95.00	93.41

Date 29 Sep 2016
Fish species Cardinalfish (100%)

Dead bait weight (kg)	Total Catch (kg)	Lapse hours						
		0	2	4	6	8	10	12
Modified Tank	85	0.0	1.2	3.8	1.4	2.2		
Control Tank	63	0.0	4.0	2.0	2.6	3.0		

Accumulation weight (kg)	Total dead bait (kg)					
Modified Tank	8.6	0.0	1.2	5.0	6.4	8.6
Control Tank	11.6	0.0	4.0	6.0	8.6	11.6

Survival rate (%)	Final survival rate (%)					
Modified Tank	89.88	100.00	98.59	94.12	92.47	89.88
Control Tank	81.59	100.00	93.65	90.48	86.35	81.59

Date 14 Jan 2017
Fish species Cardinalfish (100%)

Dead bait weight (kg)	Total Catch (kg)	Lapse hours						
		0	2	4	6	8	10	12
Modified Tank	504	0.0	0.4	0.3	0.1	0.2	0.3	
Control Tank	186	0.0	0.8	0.3	1.0			

Accumulation weight (kg)	Total dead bait (kg)						
Modified Tank	1.3	0.0	0.4	0.7	0.8	1.0	1.3
Control Tank	2.1	0.0	0.8	1.1	2.1		

Survival rate (%)	Final survival rate (%)						
Modified Tank	99.74	100.00	99.92	99.86	99.84	99.80	99.74
Control Tank	98.87	100.00	99.57	99.41	98.87		

Date 16 Jan 2017
Fish species Cardinalfish (90%), Silver sprat (10%)

Dead bait weight (kg)	Total Catch (kg)	Lapse hours						
		0	2	4	6	8	10	12
Modified Tank	295	0.0	0.3	0.2	0.4	0.2		
Control Tank	210	0.0	0.7	0.3	0.1	2.0		

Accumulation weight (kg)	Total dead bait (kg)					
Modified Tank	1.1	0.0	0.3	0.5	0.9	1.1
Control Tank	3.1	0.0	0.7	1.0	1.1	3.1

Survival rate (%)	Final survival rate (%)					
Modified Tank	99.63	100.00	99.90	99.83	99.69	99.63
Control Tank	98.52	100.00	99.67	99.52	99.48	98.52

PP-2. Technical development of tuna hand line on-board handling for fish quality improvement

1) Field technical report of the Pilot Project 2

2) Monitoring survey report of Pilot Project 2 by MNU

Project for Formulation of Master Plan for

Sustainable Fisheries (MASPLAN)

Field technical report of the pilot project 2

Technical development of tuna hand line on-board handling

for fish quality improvement

March, 2017

Morimitsu Ritsuo (Fishing Technology)

Table of contents

Appendix lists

1. Outline of Pilot Project

In the offshore fishery sub-sector, "Pilot Project for the technical development of tuna hand line on-board handling for quality improvement (PP-2)" was implemented with the aim of verifying the validity and effectiveness of master plan development.

In addition, the data and contents obtained from the survey activities of this project will be fully reflected in the Maldives' Fisheries Sector Development Master Plan after sufficient technical consideration.

In this project, we decided to compare the result obtained by practicing the method which seems to be effective for improving the quality of tuna with the result of general onboard processing method and to monitor its superiority.

1.1 The aims of the project and activities

In this project we will verify that the ratio of A / B grade of tuna for export will be improved by improving handling of tuna at the time of fishing and preservation method on board.

Overall goal:

① The developed techniques and methods are extended among for tuna hand-line fishing boats.

Project purpose：

① Quality of yellowfin tuna is improved through development of fishing techniques and methods of on-board handling

Outputs:

① The hand line fishing techniques for yellowfin tuna including the methods of on-board handling are improved in terms of quality control of fish

② Fishers of the experimental boat acquire the skills of new fishing techniques

③ Fish quality monitoring is carried out on-board

1.2 Implementation system

"Pilot Project for the technical development of tuna hand line on-board handling for quality improvement (PP-2) was carried out with an offshore sub-sector working group (SSWG), Ministry of Agriculture and Fisheries (MoFA), Maldives National University (MNU), JICA Consultant Team, Tuna Processing Export Company (ENSIS), and monitoring fishing boat as a joint project. This PP-2 is also joint implementation with post-harvest / added value improvement PP SSWG.

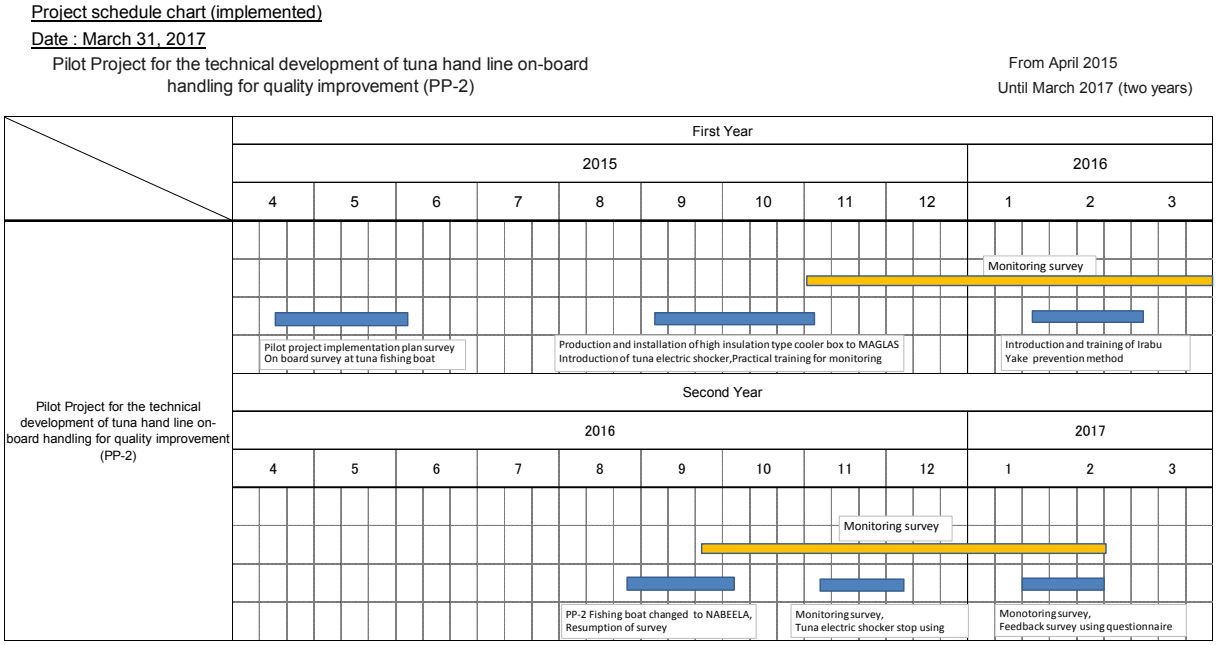
Fishing vessels of PP - 2 are basically selling their catches to tuna processing export company ENSIS, and the company conducts quality checks one by one when buying tuna from fishers. In

this project, we decided to utilize grading of tuna quality by ENSIS as an indicator of comparative study of samples and collected the results by monitoring survey.

There was a problem with the fishing capability of the first PP-2 fishing boat MAGLAS. For that reason, in the activities since September 2016 NABEELA became PP-2 fishing vessel by ENSIS. Also, due to the change of member of MNU's monitoring team, the project implementation system was forced to some changes.

1.3 Activation process

Table 1: PP-2 Activity Schedule (performed)



2. Detailed plan survey conducted

Implementation of "Pilot Project for the technical development of tuna hand line on-board handling for quality improvement (PP-2)" was decided at the meeting of the offshore fishery sub-sector and working group (SSWG) from January 20 to March 2015.

For this reason, Morimitsu (fishing technology) and Echigo (fishery resource management) conducted the offshore fishery SSWG pilot project implementation plan survey from April 18th to June 6th 2015. As a result of the survey, PP - 2 decided to compare the quality of tuna by Maldives fisherman's on-board processing method and the method proposed by MASPLAN.

MASPLAN: The Republic of Maldives Project for the Formulation of Master Plan for Sustainable Fisheries

2.1 Confirmation of current situation by field survey

In order to consider the response to PP-2 in the Maldives, on boat survey was conducted with a tuna hand-line fishing boat Khazaanaa to investigate the fishing method and preservation characteristics of yellowfin tuna. In addition, we visited the ENSIS processing plant to investigate the criteria of grading and the processing method of yellowfin tuna.

2.2 Problems concerning maintenance of freshness of tuna

In Maldives, the catch of the yellowfin tuna has been increasing in recent years and it is an important export item, but it is a problem that there are many fished species with degraded quality such as "YAKE" in the center of the fish body.

Specifically, the following two things were confirmed as a result of onboard survey at tuna hand-line fishing boat and investigation at ENSIS company's processing site

- Generally tuna export fishery companies conduct grade of tuna (A, B, C (R is not eligible)), but the ratio of tuna with high grade is low. (A grade is about 25%)
- In the Maldives, there are many tuna whose quality is deteriorated due to "YAKE" which greatly influences grade judgment.

In the tuna fishing boat which carried out the onboard survey, there were no problems in the method of processing on the deck and the subsequent storage method, but the quality of the yellowfin tuna deteriorates automatically according to the number of operation days required for one trip. But fishers sometimes stay in the sea until making full of fishes in the cooler boxes when the price of tuna is low for the purpose of saving operational expenses. Therefore, the operation period required to be long.

In addition, since the “YAKE” is greatly affected by internal body temperature and cooling method when fishing, proper handling on deck is important for maintaining the freshness of tuna. Especially in sea areas of Maldives where the seawater temperature is high, the influence on tuna is considered to be large.

*1「YAKE」: At the time of tuna’s body temperature rises due to rampage during catching, the color of the fish meat around the backbone changes to white or brown and deteriorating quality and taste. This occurs because the tuna central part was not sufficiently cooled in the early stage.

Tuna onboard handling methods commonly done in Japan and Maldives are as follows.

Table 2: Tuna handling on board

Japanese style	Maldives style
① When tuna comes up on the surface of the water fishers drive the spear in the gills to drain blood in the sea and at the	① Hook up the tuna that has risen on the surface of the water with gaff and load it on board.

same time prevent fishing escape. Also, this process reduces the rampage of tuna on board. ② Destroy the nerve on the head of the tuna on the sponge mat and immediately kill, then remove the gills and internal organs. ③ Destroy the neural tube from the tuna head to the tail with a wire and stop the movement of the fish body completely. Then wash away the blood of the head and abdominal cavity with seawater. ④ Keep tuna in ice sea water fish hold.	② Hit the head of the tuna by wooden hammer and kill it immediately, then remove the gills and the internal organs. ③ Clean the fish body with sea water and store it in ice sea water.

2.3 Measures for the improvement of freshness of tuna

(1) Basic policy

Based on information on current yellowfin tuna handling method obtained from the onboard survey, several countermeasures to improve the quality of yellowfin tuna conducted in the pilot project such as high insulation cooler box, Irabu Yake prevention method and tuna electric shocker.

Specific proposals from the JICA expert team to Ministry of Fisheries and Agriculture (MoFA) and ENSIS are as follows.

- Highly insulated cooler box

  Manufacture four highly insulated cooler boxes. Inside of the two cooler boxes will be divided into two by putting partitions for the purpose of refrigerating the tuna in a short time and saving ice consumption. Regarding the cold storage efficiency, the standard cooler box and the highly insulated cooler box is compared and verified at PP-2 fishing boat and other fishing boats that cooperate in the survey.

- Irabu Yake prevention method (Irabu Method)

  PP-2 has the plan to introduce the Irabu Method which was developed and greatly contributed to improve the quality of yellow-fin tuna in Okinawa Prefecture. By using that method, we tried to compare the occurrence of Yake between the general onboard handling method of Maldives and Irabu method. Initially, it was supposed to destroy nerve by coring (immediately kill, shed blood, removal inner guts), but was canceled by introducing the Irabu Method.

Column：Irabu Yake prevention method (Irabu Method)

"Yake" is a fish meat degenerative phenomenon found in caught skipjack and tuna. When the fish died with struggling strongly, the center temperature of the fish becomes too high and changes color look like to boiled fish meat.

It has been regarded as a major problem in the Maldives because it appears in fishing catches particularly in high water temperature. Those in which Yake occurred cannot be sold for sashimi and fish prices are generally low

This problem was serious also in Okinawa yellowfin tuna hand-line fishery. Coping with this issue, the "Irabu Method" was developed by Irabu Fisheries Cooperative as a countermeasure.

This method does not immediately kill the yellowfin tuna after loading on deck; it carries out the keeping live tuna in the cold seawater for a while for lowering the temperature of the fish body core part. This method has already been approved in the study of Okinawa Prefectural Fisheries Experimental Station.

(2002 Okinawa Prefectural Fisheries Experimental Station Project Report)

- Tuna electric shocker

  The aims of using tuna electric shocker is to reduce the tuna body temperature which easily rise by rampage of the fish, shortening the time of tuna catch and improve fishing efficiency.

- Destruction of tuna's nerves

  The plan of nerve destruction of tuna has been canceled due to the introduction of the Irabu Method.

(2) Assumed major equipment

Table 3: PP-2 equipment

(Unit: yen)

No	Item name	Maker	Specification · Model	quantity
1	Tuna electric shocker	Yamada Jitugyo	Tuna electric shocker M type 1 set	2
2	Digital thermometer	Tanita	TT-508（white）	2
3	Digital thermometer	Doritec	Digital thermometer Gurie	3
4	High-insulation type cooler box	Local procurement	1.22m×2.44m×1.11m	4

(3) Discussion on monitoring method

PP-2 monitoring method has determined through SSWG meeting as follows.

① sample： Tuna quality comparative experiment is carried out by comparison of the normal

method of fishers and Irabu Method. In addition, we compare the difference in grade judgment at the time of landing between standard type cooler box and highly insulated cooler box.

② Observer and fishers will practice the tuna handling method proposed from the project.

③ Survey items: Record necessary information to monitoring sheet and attaching tag to tuna for the comparison of grading results by ENSIS.

④ Monitoring sheet: Monitoring sheet will be prepared by project team.

⑤ Monitoring time and frequency: Of course, It depends on the weather condition, but need to conduct one trip survey every month. Monitoring team should contact to the PP-2 fishing boat captain in advance to arrange the survey schedule.

⑥ Monitoring observer: Person in charge should be dispatched from MNU research team.

⑦ Monthly report of monitoring results: The MNU survey team shall prepare the monitoring report and submit it to MASPLAN within one week after the survey trip. The report shall describe recorded data, special notes on the survey situation, proposals and evaluations from fishers.

⑧ Final report: The MNU research team prepares and submits the survey result report within one month after completion of the monitoring period of August 2016. In preparing the report, MNU team needs to consult with the MASPLAN in advance.

(4) Monitoring implementation system

Since the PP-2 fishing boat basically sells their catches to tuna processing export company ENSIS and hence ENSIS records the tuna grading result when buying from the fishing boat PP-2. The research team of the university will conduct a boarding survey and grading results from ENSIS and carry out a one-year monitoring survey. In order to joint monitoring research with external institutions, we asked the University of Vila and the National University of Maldives (MNU) for the cooperation of survey work. After that, we planned to select one of the universities for carrying out monitoring survey and eventually decided to form a joint research with the Maldives National University (MNU).

3. Introduction of highly insulated cooler box

In order to improve the preservation state of tuna as planned "2.3 Measures for the improvement of freshness of tuna", we planned to manufacture four highly insulated cooler boxes. However, due to over budget, the two units were manufactured. One of them was manufactured to be two compartments with a partition and used as a precooling tank of the Irabu Method to verify the effectiveness against to "Yake".

In the Maldives, caught yellowfin tuna is kept in the cooler box installed on the deck, but exposure area touched with outside air is larger than the fish hold tank that is installed beneath the deck in the fishing boat. From such a viewpoint, it can be considered that the cold storage

efficiency of the cooler box is low, so it is necessary to improve the cold storage efficiency by the highly insulated cooler box.

As for the measure to improve the cold storage efficiency, mounting an awning (tent roof) on the deck to avoid direct sunlight to the cooler box was planned, but the plan was canceled because many of the fishing boats are combined with skipjack pole-and-line fishery.

3.1 Improvement items and design

① Insulation material that enhances cold storage efficiency

The outer dimensions of the highly insulated cooler box were the same as those of existing ones, but the insulation was increased 1.5 times to increase the cold insulation effect and the inner lid was newly prepared. (Fig. 1, 3)

② Mounting the partition inside the box

One of the two cooler boxes was made with a partition in the center in order to reduce the ice consumption and movement of the fish due to rolling or pitching of the fishing boat. This makes it easy to manage the temperature inside in each portion. (Fig. 2)

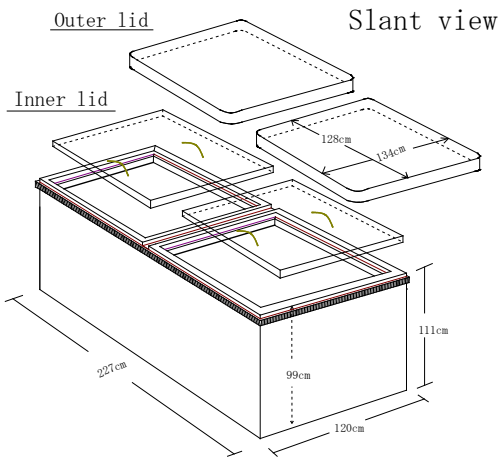


Fig.1 Highly insulated cooler box (1)

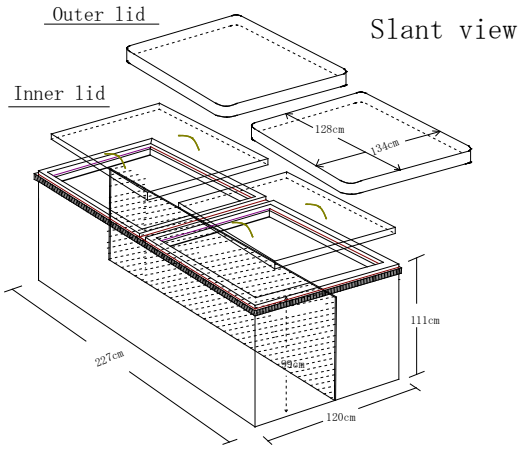


Fig.2 Highly insulated cooler box (with partition)

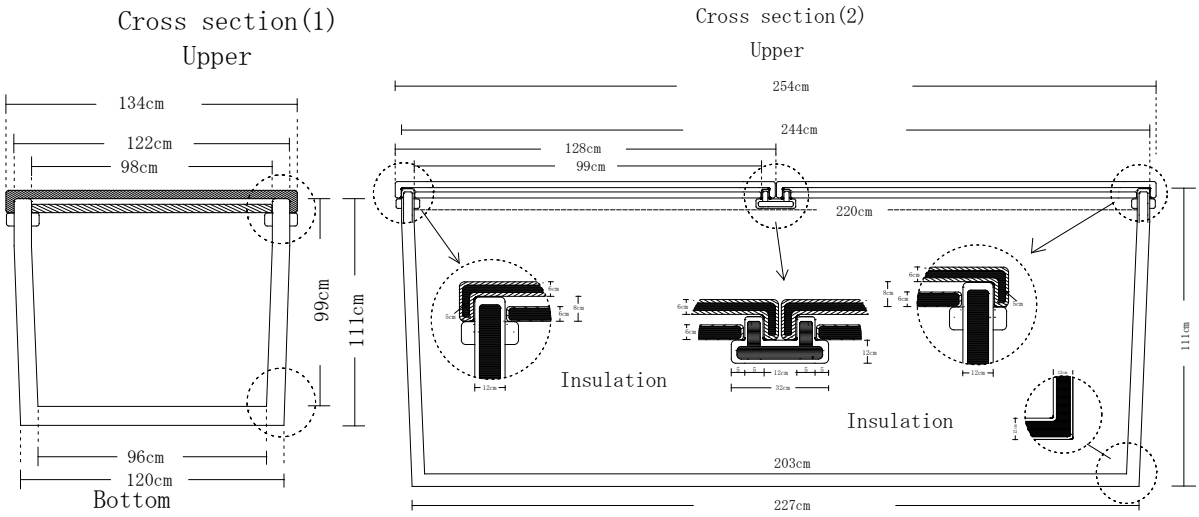


Fig.3 Highly insulated cooler box (Cross section)

3.2 Highly insulated cooler box manufacturing work

The manufactures of the highly insulated cooler box was designed by JICA expert and ordered to the FRP engineer at the FAD center which is a facility of MoFA. The first one was completed on October 14th, on that day the cooler box was loaded on the PP-2 fishing boat MAGLAS and installed with the cooperation of ENSIS. However, the second cooler box was completed on October 21, it was not in time for the training operation and consequently we decided to complete the installation work next time.

It was judged that the cold storage capability of highly insulated cooler box was higher than that of ordinal cooler box from the point of melting speed of ice in the cooler box. The detailed performance was continued to be evaluated during the monitoring survey period.

4. Introduction of Irabu Method

4.1 Purpose of introduction

"Irabu Method" was developed by Mr. Junya Iraha of Irabu Fisheries Cooperative of Okinawa Prefecture to prevent the deterioration of fish meat by Yake. Its effectiveness is also described and verified in Okinawa Prefecture's "occurrence of Yake condition of tuna and that prevention method".

From that reason, Irabu Method was introduced for the verification whether it is effective or not for the Yake of yellowfin tuna occurring in the Maldives which are similar weather condition in Okinawa.

The project has decided to compare the quality of tuna between the "Irabu Method" proposed for improving the quality of tuna and the method commonly used by tuna fishing fishers in Maldives.

4.2 Features of Irabu Method

The idea of Irabu Method is to use the tuna's blood circulation system to cool the core part of the fish body. In other words, caught tuna should be put in low temperature seawater immediately without fatal damage for effective heat exchange.

For this, it is important to let the tuna keep alive as longer as possible in the pre-cooler tank, so when hooking tuna by gaff at the time of landing up on the deck it is required to avoid the mass bleeding from fatal damage. (See the above-mentioned column)

4.3 Work process of "Maldives method" and "Irabu Method "

<Handling process of Maldives >

① Hook the tuna that came up near the surface of the sea by gaff and lift up to the deck.

② Hit the tuna head with a wooden club and kill it immediately then remove the gill and the inner guts.

③ Clean the fish body and abdominal cavity with sea water and store it in ice seawater.

A scene of hooking by gaff

Hitting tuna head by wooden club

Removing of inner gut and gill

Storing tuna in cooler box

Figure 4　Fish handling on the deck by Maldives method

<Handling process of Irabu Method >

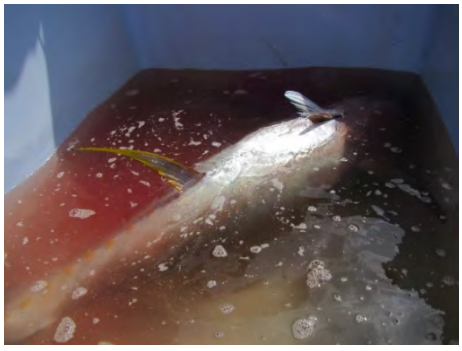
① Prepare two or more fish tanks, one of which is set to cold sea water of 10 to 15℃ and used as a pre-cooling seawater tank.

② Place the live tuna in the pre-cooling seawater tank for about 50 to 60 minutes.

③ Taking it out from the pre-cooling seawater tank and remove the gill and inner guts.

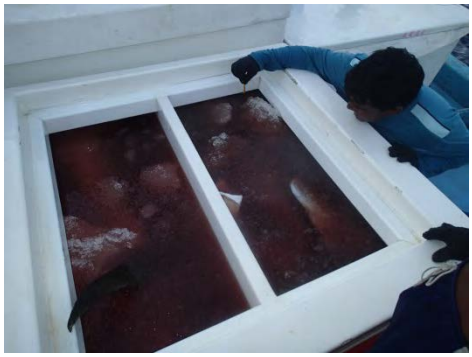
④ Transfer it to a highly insulated cooler box of ice sea water and preserve it.

* In this project, we plan to use ice sea water in the pre-cooling tank for the Irabu method.



Preparation of pre-cooling sea water tank

Placed live tuna in tank



Cleaning work after removing of inner guts

Stored tuna in ice sea water tank

Figure 5　Fish handling on the deck by Irabu Method

5. Introduction of tuna electric shocker

5.1 purpose of introduction

Introduction of tuna electric shocker is aimed at preventing the temperature rise in tuna by temporarily stopping the movement of tuna in the sea. In addition to that, it also contributes to preventing degradation of quality of fish due to "Yake" caused by rising body temperature from tuna ramping at the time of fishing and short operating time by improving fishing efficiency.

Figure 6 Tuna Electric Shocker

5.2 Characteristics of tuna electric shocker

Electric tuna shocker is a device that stops rampage the large fish by electric shock and captured by minimizing damage of fish body. With the introduction of this device, there is an advantage that tuna can be taken in easily when comes up to the shallow water area.

The tuna electric shocker was tested for 4 yellowfin tunas (30 to 60 kg) in total during the operation training before the PP-2 monitoring survey. At the time of trial, tuna struggling was stopped instantly by the tuna shocker and the intended effect was confirmed. However, the problem that the electrode cable cannot be used unless near the water surface by short cable.

5.3 Safety measure

Regarding the use of tuna electric shocker, safety knowledge on sufficient safety management and usage is necessary. For this reason, "Tuna shocker M type Manual English 2015" produced by the manufacturer and safety instruction manual "Important Safety Instructions" were prepared for profound understanding of fishers and monitoring observer.

The safety instruction on tuna electrical shocker operation was conducted by JICA expert to observer and fishers at PP-2 fishing boat MAGLAS and NABEELA in each occasion.

6. Training for fishers and observers

Necessary training for survey was conducted to fishers and observers for the strengthening of

monitoring system. This training was carried out every time when the survey observer and the PP-2 fishing boat changed.

6.1 Pre-Monitoring Workshop

October 11, 2015 prior to the monitoring survey, training workshop was held for the purpose of sharing information and implementation contents of the survey. The contents of the workshop were as follows.

① Japanese tuna fishery and fish freshness management technology (presentation, video)

② Discussion on the difference between Maldives and Japanese tuna fishery (especially tuna hand-line fishery on the coast)

③ Survey method

- How to fill the monitoring sheet
- Safety management and usage of tuna electric shocker
- Work process of 'Irabu Method'
- Handling method of tuna from fishing up to ice preservation (FAO text)

6.2 Observer's training on board

In the 1st on board training on October 17, 2015 at sea, although the work process was instructed to the monitoring observer in detail and prepared for the trial, the "Irabu Method" had not implemented by poor catches of yellowfin tuna. It was regrettable results because the preparation of monitoring survey has already completed. And the process of Irabu Method was instructed again to new observer from MoFA by JICA expert on February 16, 2016. The results of all grade judgment and comparisons were obtained through these monitoring training systems.

7. Monitoring survey

As soon as the monitoring survey starts, first observer in charge was dismissed and then it took too times to appoint new observer. Subsequently, two MoFA staff members were appointed as monitoring observers, but the monitoring was not carried out for a long period because the schedule could not be adjusted with the unpredictable operation style of PP-2 fishing boat. In addition, MAGLAS had a fatal problem that the number of catch of yellowfin tuna was small, for that reason it was impossible to obtain a sufficient sample.

As for each of these difficulties, JICA experts explained to the SSWG member about meaning of the project and importance of the monitoring survey. As a result, from September 2016 PP-2 fishing vessel was changed to NABEELA, and substantial investigation activity was started gradually.

JICA experts accompanied as much as possible with observer during the on board survey for conducting guidance and technology transfer, and confirmed the effects of the introduced new

technologies

7.1 Implementation system of survey

As mentioned earlier, the monitoring was carried out by the following members, although there were changes such as PP-2 fishing boat and survey observer.

Table 4: PP-2 Monitoring Survey Implementation Structure

Affiliation	Title	Name
PP-2fishing boat MAGLAS	Owner	ENSIS／Mr. Ali Ahmed (Person in charge)
October 2015 - August 2016	Captain	Mr. Ali Ibrahim
PP-2fishing boat NABEELA	Owner	ENSIS／Mr. Ali Ahmed (Person in charge)
September 2016 - March 2017	Captain	Mr. Ismail Shafeeg
Maldives National University（MNU）	Research Director	Dr. Shazla Mohamed
	Research assistant	Mr. Ahmed Saeed（MNU） →（February 2016~） Mr. Ibrahim Fikree（MoFA）
	Observer1	Mr. Ahmed Saeed（MNU） →（February 2016~）Mr. Ahsan Mohamed (MoFA)
	Observer2	（February 2016~）Mr. Nazim Moosa(MoFA)
Ministry of fisheries and Agriculture（MoFA）	MoFA	Mr. Adam Manik
	MRC	Mr. Riyaz Jauharee
JICA Expert	Fishing technology	Morimitsu Ritsuo
	Fisheries resource management	Echigo Manabu

7.2 PP-2 fishing boat

At the start of this project in August 2015, installation of tuna electric shocker and highly insulated cooler box to PP-2 fishing boat MAGLAS that was determined with full cooperation of yellowfin tuna processing export company ENSIS.

Since started monitoring survey by MAGLAS, the status of yellowfin tuna catches were very bad. Consequently, the member of SSWG had a meeting with ENSIS which owns a PP-2 fishing boat MAGLAS at MRC before JICA expert return to Japan for taking measures against the problem of poor catch.

On March 3, 2016, finally ENSIS had selected NABEELA belonging to the company as a PP-2 fishing boat.

As a result, since September 2016, monitoring surveys were continuously conducted at NABEELA, and consequently 4 times of monitoring data could be obtained by the end of the monitoring survey period on March 2017.

Figure: 7 PP-2 fishing boat MAGLAS

Figure: 8 PP-2 fishing boat NABEELA

7.3 Result of monitoring survey

The monitoring survey was conducted four times during the period from November 2016 to February 2017. Details are as follows.

Table 5: PP-2 fishing boat monitoring survey at NABEELA

Times	Period of survey	Observer
1st	Boarding survey (11-17 November 2016) Trip period (12-22 November 2016)	Ahsan Mohamed Morimitsu
2nd	Boarding survey (25-30 November 2016) Trip period (25th November to 7th December 2016)	Morimitsu
3rd	Boarding survey (6-19 January 2017) Trip period (6-25 January 2017)	Ahsan Mohamed
4th	Boarding survey (8-14 February 2017) Trip period (8-22 February 2017)	Morimitsu

In the monitoring survey, all the caught yellowfin tuna were targeted during the operation period of the fishing boat (Irabu Method was examined only the time of observer on-boarding).

Comparison of the results of grading was implemented between the Irabu Method and usual handling method of the fishers. For the preservation of tuna, only ice sea water was applied in cooler box.

Regarding the use of tuna electric shocker, problems requiring some improvement were confirmed but since it cannot be solved, it was discontinued from the second monitoring survey. (See "7.5 Issues and Improvements in Monitoring Survey").

The results and graphs obtained by each monitoring survey are as follows.

① 1st monitoring survey result (Boarding period: November 11 - 17, 2016)

The total number of catch fish during the monitoring period was 54 fishes. Within 8 of these were handled (11/12 (4), 11/13 (3), 11/15 (1)) with Irabu Method (written as Irabu). Others were handled with usual way + seawater ice (Standard, Control). During this monitoring survey period, tuna electric shocker was used for almost all yellowfin tuna. Table 6 and Figure 9 show the results of grading (catch ratio) according to handling methods.

Table 6: Grading results by handling method (1st survey)

	Number of fishes					
	A+	A	B+	B	C	R
Irabu		3	3	2		
Control		8	3	13	5	5
Standard		2	1	5	2	2

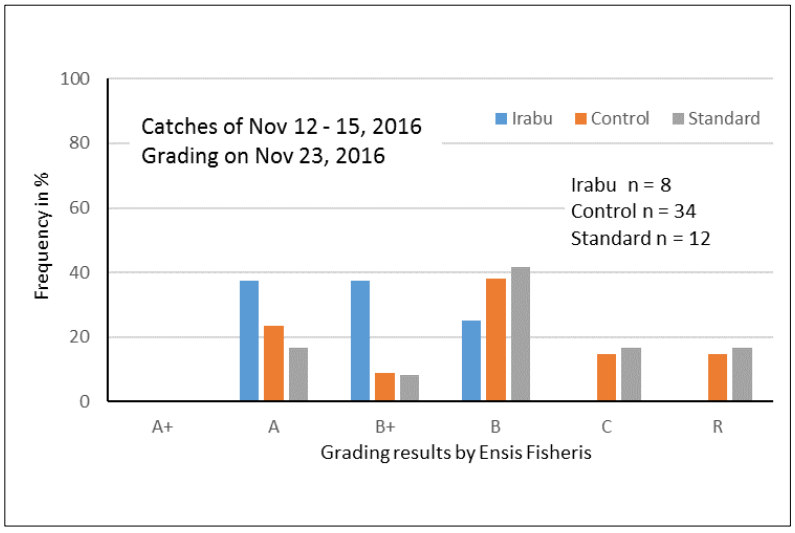


Figure 9: Distribution of grading results by handling method (1st survey)

② 2nd monitoring survey result (Boarding period: November 25 - 30, 2016)

In this survey, 13 yellowfin tuna were handled by Irabu Method and 30 yellowfin tuna were handled by ordinary method. All catches in this survey were preserved in ice sea water. As for the tuna electric shocker, since there is a problem in operation as will be described later, we canceled its use in this survey. The results of the grading survey are shown in Table 7 and Figure 10

Table 7: Grading results by handling method (2nd survey)

	Number of fishes					
	A+	A	B+	B	C	R
Irabu			2	11		
Control	2	7	6	19	14	9

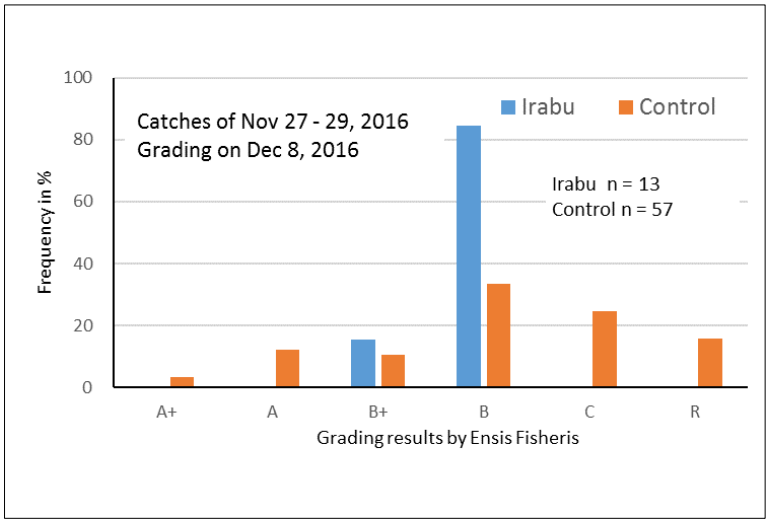


Figure 10: Distribution of grading results by handling method (2nd survey)

③ 3rd monitoring survey result (Boarding period: January 6 - 19, 2017)

In this monitoring survey was conducted by one observer at PP-2 fishing boat. 15 yellowfin tuna were handled by Irabu Method and 57 yellowfin tuna were handled by ordinary method. All catches in this survey were preserved in ice sea water. The results of the grading survey are shown in Table 8 and Figure 11

Table 8: Grading results by handling method (3rd survey)

	Number of fishes					
	A+	A	B+	B	C	R
Irabu		5	3	7		
Control		3	0	23	1	9

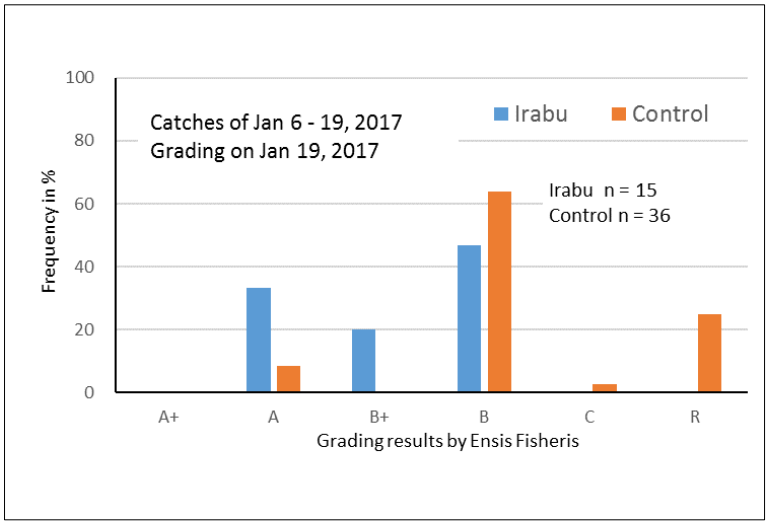


Figure 11: Distribution of grading results by handling method (3rd survey)

④ 4th monitoring survey result (Boarding period: February 8 - 14, 2017)

Among the 19 fishes caught on February 12, 2017, the Irabu Method was 5 and the usual method was 14 and all were preserved in ice seawater.

The results of the grading survey are shown in Table 9 and Fig-12.

Table 9: Grading results by handling method (4th survey)

	Number of fishes					
	A+	A	B+	B	C	R
Irabu		1	2	2		
Control		5	1	5	2	1

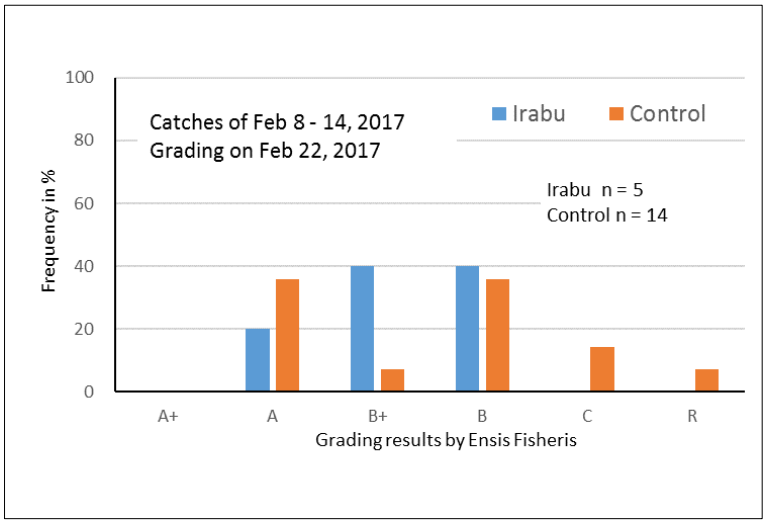


Figure 12: Distribution of grading results by handling method (4th survey)

Based on the results of a total of four monitoring surveys, the catch handled in the Irabu Method was distributed from A grade to B grade, with all samples having B grade or higher. Low grade of C

and R grade were not appeared. Meanwhile, in the Maldives handling method had the distribution ranges from A grade to R grade (those for which buying is refused). From this result, it is considered that the handling by the Irabu Method has the effect of decreasing Yake and improving the fish quality as compared with the conventional method of Maldives.

In addition, since analysis and evaluation on the monitoring survey is supposed to be summarized as a monitoring report by MNU. Please refer to the report from MNU.

8 Project evaluation from fishers (PP-2 fishing boat NABEELA)

In order to obtain qualitative evaluations from NABEELA fishers such as tasks faced in the project and obtained knowledge, questionnaire form was prepared and interviewed.

The main questionnaire items are as follows.

- General impression on this project including method of monitoring, behaviors and approach of researchers and technicians, high-insulated cooler box, tuna electronic shocker, etc.
- Effectiveness of Irabu Method;
- Evaluation of the high-insulated cooler box such as size, cooling capability, technical issue, feasibility, etc.
- Countermeasure required for improvement of quality of tuna

The survey was conducted by the captain's explanation of each item of the questionnaire in Dhivehi and then the crews answered the questions. The data from the monitoring surveys clearly showed that *Irabu* method was more effective for keeping quality of tuna than standard method; however, some of the crews of NABEELA were not of the same opinion in this regard. This discrepancy of opinions might reflect insufficient explanation in Dhivehi regarding the results of the monitoring surveys. Actually, the monitoring surveys on the NABEELA had been conducted only four times since September 2016, and replacements of crews also happened during the period. Therefore, there was a possibility that some crews lacked sufficient understanding of the aim and plan of PP-2.

Table 10: Summary of interviews

Question	Very good	Good	Ordinary	bad	Very bad	Total
Is this examination effective for improving the freshness of tuna?	1	3	4	0	0	8
How is the performance of the new modified cooler box?	5	2	1	0	0	8
How about data collection by monitoring?	6	2	0	0	0	8

How is the impression of tuna electric shocker?	6	2	0	0	0	8

For the interview survey results, please refer to Appendix 1 "The total result of questionnaire for the technical development of on-board tuna handling (PP-2)"

9. Other findings obtained through project implementation

9.1 Selection of the project fishing boat

The fishing boat MAGLAS was designated for the project at the beginning of PP-2, in cooperation with ENSIS tuna processing and exporting company. The equipment and materials were procured and installed to the MAGLAS to start the monitoring surveys. Unfortunately, however, MAGLAS was not successful in catching enough tuna for sampling. To solve this, we had a discussion with ENSIS on the occasion of the SSWG meeting, and as a result the vessel for PP-2 was replaced to NABEELA and the monitoring surveys were finally started. ENSIS was supposed to provide a fishing boat for PP-2 without charter fee and we had to wait for ENSIS to provide the project fishing boat. Actually, the monitoring surveys were suspended for 11 months since October 2015, which caused a serious loss for the project in terms of limited time, labor and budget. In case of a project affected by natural environment such as sea condition, a fishing boat to be used in the project needs to be selected with due consideration.

9.2 Project site

ENSIS was conveniently located in terms of the project implementation. Maldives is an island country extending 800km from north to south, and the fishing ground for yellowfin tuna seasonally changes from area to area. ENSIS is one of the largest companies for tuna processing and exporting in the country, based at Hulhumale in Male Atoll, the center of the country. Many tuna hand-line fishing boats unload fish catch and could supplied ice and fuel at Hulhumale Port. In addition, the port was more easier to moor anchor than Male Port. Therefore, both MAGLAS and NABEELA were based at Hulhumale.

ENSIS had a lot of experiences and reliability in grading tuna, and contributed to evaluation of quality of the fish caught in the project. In this sense, ENSIS met the requirements for a cooperative company of the project.

9.3 Cooperating company of the project

Improvement of quality of yellowfin tuna was an important issue to be sorted out for fishing companies such as ENSIS in Maldives, as mainly low-quality tuna was on the market at the moment. Therefore, ENSIS showed a strong interest in the project and authorized installation of the highly insulated cooler box as well as the tuna electronic shocker to the project fishing boat.

ENSIS was also willing to cooperate with the monitoring survey. Such a cooperative company was indispensable for the implementation of this pilot project, and had an influence on the success of the project. In this sense, win-win partnership with the cooperative company should be built in the project.

9.4 Issues of monitoring surveys

At the initial stage of the surveys, it took a long time to nominate observers after the resignation of first observer. This was because there were few qualified personnel to get on-board for one to two weeks. In addition, the fish catch by the PP-2 fishing boat MAGLAS was too small to carry out monitoring for a while.

After that, although the staff from MoFA was designated for an observer, the planned number of times for monitoring surveys was not implemented due to lack of coordination in the monitoring team comprising the boat owner ENSIS, captain of the MAGLAS, MNU and MoFA observer. This is undeniable that the possibility of weak motivation mind to cooperate with the monitoring survey which does not produce profit because the PP-2 fishing boat is a commercial fishing boat and the crew's income is relied by the catch of the tuna. It was difficult to coordinate with PP-2 fishing boat during the fishing trips since the fishing were subject to weather and sea condition. In addition, we were sometimes unable to communicate with each other as there was no network of cellphone during most of fishing trips.

From these experience, it is important that the monitoring surveys should be scheduled to concentrate on the period of good yellowfin tuna fishing seasons because the tuna catches significantly fluctuated by month.

10 Effect of high-insulated cooler box

Two highly insulated cooler boxes were manufactured and their performance was verified. One box had a partition inside to separate into two portions, each of which was used one by one in accordance with the amount of fish catch for economize on ice consumption. The other box had no partition but high performance by thick insulation materials, which received good reputations from fishers.

	
Highly insulated cooler box	Highly insulated cooler box (with partition)
	
Highly insulated cooler box (without partition)	Regular cooler box

Fig-13: Ice Condition in the Cooler Boxes 15 Days Later

11 Feasibility of Tuna Electronic Shocker

In the beginning of the project, introduction of the tuna electronic shocker was planned in terms of quality improvement of tuna. However, we unfortunately found out that the device was not practical due to shortage of electricity energizing time. Actually, it would be difficult to utilize the device for the following reasons. In the monitoring survey results, although it was not possible to confirm the evidence that electric shocker is effective for improving the quality of yellowfin tuna; fishers were generally interested in tuna electric shocker.

Fig-14: Tuna Electronic Shocker

Problems in using tuna electric shocker are as follows.

- It is not possible to make effective shock unless the snap rings (electrodes) contact directly to fish body
- The snap rings even without electricity may cause raging of tuna, detach and escape from fishhook
- The device is designed to automatically stop energizing time for four seconds for safety

reasons

- 20 meter cable of the device is too short to shoot the snap ring toward tuna unless the tuna is close to the boat
- Even 30 meter cable is difficult to make the energized snap rings hit the tuna, especially at rough sea
- Therefore, the snap rings must be energized before hitting to the fish, but for example, if it is energized three seconds before hitting to fish body, the time for contacting the fish body will be only one second and tuna may escape to the contrary.
- In the event of failure at the first trial, the second trial would not be in time for targeting the same tuna.

One of the solutions was to modify the device to extend the energizing time, but the manufacturer replied that it would be not acceptable for safety reasons. We decided to suspend the introduction of the tuna electric shocker in the project, as it should not be modified without authorization from the manufacturer in respect of safety first on-board.

12. Future tasks and recommendations

12.1 Overall evaluation

PP-2 implementation was delayed due to various circumstances, but monitoring and analysis data could be obtained. As a result, it became clear that the Irabu Method is effective for maintaining freshness and quality of tuna. Throughout PP-2, it turned out that there are few human resources working within the government of the Maldives and that it is not in a situation where it is possible to jointly manage projects.

Also, the project met some difficulties due to delays in the decision of the successor after the first observer resigned, continuation of monitoring due to a small number of tuna catches and lack of cooperation within the project members, etc. From now on, the project should be promoted in consideration of measures concerning these various problems.

12.2 Recommendations concerning future survey

Through PP-2, it was the achievement that the effect of improving freshness and quality maintenance of tuna was confirmed by Irabu Method will lead to the future.

In most fishing boats, fish catch are kept in ice seawater. In this case, the seawater will become dirty with blood of tuna, which may lead to lowering quality. To avoid this, 12 hours after cooling tuna in the ice seawater, the tuna should be transferred to another cooler box. This must be effective for quality improvement in spite of increase of time and labor. For this method, I would like to propose to conduct surveys by stakeholders.

In addition to this, we should continue to conduct surveys to maintain and improve the freshness of tuna by using the Irabu Method or other methods through collecting enough samples and data. Also, in order to smoothly conduct future surveys, there is a need to deal with human resources and changes in fishing seasons.

PP-2 is over, so Maldives themselves need to work by their own initiative in order to gather data on future surveys.

12.3 Recommendations for highly insulated cooler box

In this project, two highly insulated cooler boxes were produced locally and the effectiveness was verified. As a result, it was evaluated that the highly insulated cooler box is useful in Maldives. As already mentioned at the beginning, fishers tend not to return to the port until the full catches of tuna when the fish price is cheap. Consequently, the fishing trip period become longer and the quality of fish also become worse.

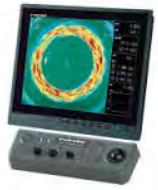
For preventing this situation, this highly insulated cooler box will be indispensable in order to cope with extreme quality deterioration of tuna kept for a long time.

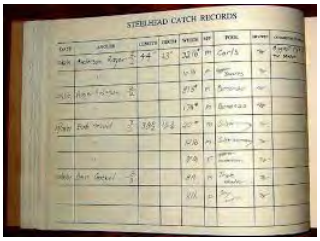
Introduction of a high-insulated cooler box costs a certain cost, but it can not only be used for a long term, but also increases the quality of fish and reduces the consumption of ice. As a result, economic advantages will increase, so it should be disseminated to tuna hand-line fishing fishers.

12.4 Recommendations for tuna hand line fishing

① Most tuna fishing boats are equipped with live baitfish tanks and large cooler boxes behind the bridge. The weight of the cooler box increases because of fish catch and ice during fishing operations, which may cause instability while moving due to wind and waves. This may also cause a serious accident and therefore precaution by the Government as well as safety measure by the boat owner will be required.

② Most of tuna hand line fishing boats are equipped with GPS, communication radio and VMS (vessel monitoring system), but the other fishing instruments such as fish finder and electronic water thermometer are limited only for a few fishing boats. With a view to increase of catch by tracing schools of yellowfin tuna at a deeper point of the sea in the daytime, higher-performance GPS, fish finders, electronic water thermometers and sonars should be introduced.

Fish Finder	Sonar	Electronic Water Thermometer	Logbook

Fig-15: Electronic Instruments and Logbook for Tuna Hand Line Fishing

③ Schools of yellowfin tuna are also likely to move seasonally to specified area. Generally, most fishers record each of fishing operations in the logbook to accumulate the useful information for increase of fish catch, and determine the fishing ground of the day after consideration of fishing data in the past and the water temperature in the fishing ground. Therefore, it is desirable that more fishers in Maldives should use electronic water thermometer to find out the best fishing ground for yellowfin tuna.

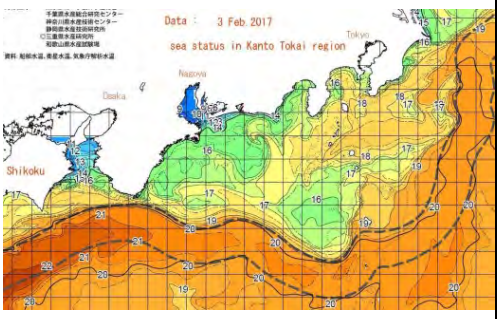


Fig-16: Water Temperature Distribution
(Source: Wakayama Fisheries Experiment Station)

Fig-17: FAD
(Source: Maldives Ministry of Agriculture & Fisheries)

④ At present, more than 50 FADs are deployed by the government in the territorial waters of Maldives, where large yellowfin tunas may be aggregated. However, skipjack pole-and-line fishing boats operates around the FADs, while tuna hand line fishing boats are unable to operate there, to avoid competition and/or conflict between both sides. Some regulations need to be introduced so that both types of fishing boats can equally operate around the FADs.

⑤ The seawater cooling circulation system has been already introduced in some fishing boat in Maldives. Using this system, no/little ice is required for cooling fish catch, and therefore the time, labor and expenditure for ice are reduced. In addition, more freshness of fish can be also expected. Initial cost for purchase and installation of the system is required, but it is worth to consider its introduction.

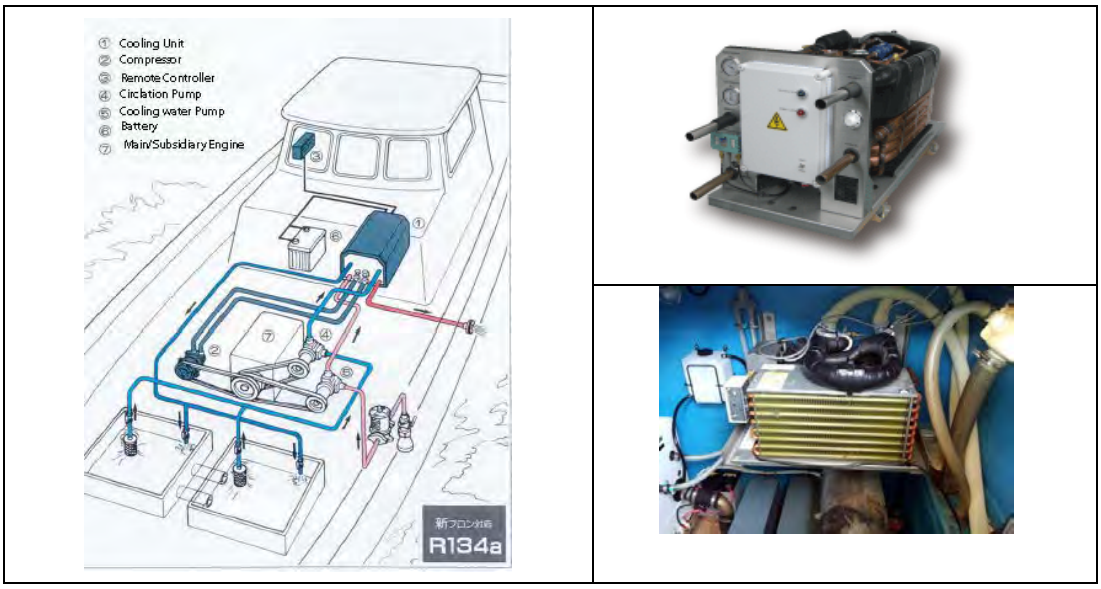


Figure 18: Seawater cooling circulation system

⑥ Fish tanks for storing catch should be fabricated with insulating materials to keep cool inside the tank. Highly insulated tanks contribute to reduction of cost of ice and keeping fish quality.

⑦ Fishing boats are subject to pitching and rolling from wind and waves at sea. In a larger fish tank, skipjack may rub and jostle each other in the tank, which causes deterioration in quality. In such cases, the size and shape of the tank should be modified so that fish catch cannot move inside the tank while moving.

12.5 Recommendations in terms of economy and sustainability

① The market price of yellowfin tuna depends on the amount of unloading of the day. If the price is not high at that time, fishers generally tend to wait for the rise of price and continue fishing operations until the fish storage is filled up. However, keeping tuna in the storage on-board for a longer period may cause deterioration of quality, which eventually has a negative influence to the fishers. Therefore, it should be corrected by the relevant authorities if the price of tuna is too low in the market.

② At present, there is a decreasing trend of the number of tuna hand line fishing boats equipped with cooler boxes on deck. Most of newly built fishing boats are designed to install fish storage beneath the deck. At construction or modification work of fishing boats, not low quality insulation but high performance materials should be adopted.

③ These efforts for quality improvement would be acceptable in the country, but another issue still remains to be sorted out in respect of fish pricing system in the fishing companies such as ENSIS. Better purchase prices should be set to the tuna with better quality and grades so that local fishers can be motivated for quality management. The Governmental programs in this regard will be expected.

Appendix: 1

The total result of questionnaire for the technical development of on-board tuna handling (PP-2)

from NABEELA fishers — 8 samples in total

1 The impression of the pilot project.

Please let me know the impression of the entire this pilot project. (Please select or describe)		Very good	Good	Ordinarily	bad	very bad	Total
①	Is it useful of this trial operation for the improvement of the quality of tuna ?	1	3	4			8
②	How is the preserving efficiency of newly modified cooler box ?	5	2	1			8
③	How was the monitoring data collection method ?	6	2				8
④	How was the tuna electric shocker ?	6	2				8
⑤	How was the working manner of monitoring observer ?	8					8
⑥	How was the working manner of expert ?	7	1				8

2 Please describe your impression of the [Irabu yake prevention method] ?

1.This way of storing/preserving tuna on-board is a beneficial method. 2.Good. But did not notice any improvements in quality 3.This method is good method, but did not notice a change in quality of fish 4.Good. But did not notice any improvements in quality 5.This way of storing/preserving tuna on-board is a good method 6.This way of storing/preserving tuna on-board is a good method, but did notice a change in quality of fish 7.Did not notice a difference

3 Did you get any new information or knowledge from this project ?

Yes	No
6	2

In case of [Yes], please describe it.

1.Gained more/different experience 2.Gained more experience and learned new things. Observed electric shocker is very efficient 3.Gained new experience 4.Gained new fishery experience 5.Gained new fishery experience and knowledge 6.Gained new fishery experience and knowledge

4 Is it possible to accept the modified cooler box to other dhoni, do you think ?

Yes	No
6	2

5 What is necessary for the improvement of the quality of tuna fish in the future, do you think?

1.Better quality ice and better quality coolbox 2.Better quality cool boxes and better quality ice 3.good quality coolbox and good quality ice 4.Acess to good quality ice 5.Access to good quality ice 6.Access to good quality ice and good quality cool box 7.Better quality ice and better quality coolbox

6 Please write your additional opinion etc. if you have anything.

Project for the Formulation of Master Plan for
Sustainable Fisheries

Monitoring Survey Report of Pilot Project 2

Technical development of tuna hand line on-board handling for fish quality improvement

Dr Shazla Mohamed
Ibrahim Fikry
Ahsan Mohamed

The Maldives National University

March 2017

Contents

Technical development of hand line tuna onboard handling for quality improvement

1 Introduction

MASPLAN is a JICA-MoFA project aimed at supporting the Government of the Maldives to formulate a mid- and long-term development plan for the fisheries sector in the Maldives. Considered as the Sustainable Fisheries Development Plan, it will support the promotion of fisheries based on the philosophy of persistent and efficient use of fishery resources in a sustainable manner. In addition, this plan is also expected to contribute to long-term environmental management and support the promotion of tourism through sustainable utilization of fisheries resources.

A major focus area of the project is the skipjack tuna pole-and-line fishery and hand line fishery for yellowfin tuna. Maldives has a long history of skipjack pole and line fishery, however the quantities of catch has been gradually decreasing from 2006. On the other hand, number of tuna hand line fishing boats have increased with a positive impact on the hand line yellowfin tuna numbers. In addition, a number of pole and line fishing boats have been converted to hand line fishing boat.

Yellowfin tuna intended for export are graded on landing to A, B, C (D is reject) before being processed and exported. Although the quality of tuna has gradually improved over the years, this is not adequate to generate the maximum profit. The ratio of A-grade tuna is still low (approximately 25%) especially due to high degree of deterioration of tuna quality as a result of YAKE formation. In Maldives, YAKE defined as low quality of fish meat caused by losing red color, elasticity and moistures, is the easiest distinguish indicator to check quality of tuna. YAKE formation can be reduced and the ratio of high quality tuna can be further enhanced by introducing strategies to improve onboard handling and preservation methods. In order to achieve this objective, a joint agreement was made between JICA team, MoFa and Ensis Fisheries Company to set-up experimental pilot project for improvement of onboard handling and preservation of hand line yellowfin tuna.

This project therefore intends to improve methods applied for onboard handling of hand line yellowfin tuna by:

a. verifying effective handling methods
b. verifying effective preservation methods

The main purpose of this study is to determine the effectiveness of Irabu method in preservation of tuna onboard in comparison to the standard method used in the Maldives.

1.1 Preliminary study onboard

Base site: ENSIS Fisheries located at Hulhumale
Fishing boat: MV. Khazaanaa (landing to ENSIS Fisheries)

On board survey to observe the current practice of handling tuna was conducted on MV Khazaanaa boat. The grading and other operations were observed at Ensis Factory in Hulhmale' where tuna caught during the trip was processed and packed for export.

In order to study the practices concerning onboard handling of tuna that contributes to freshness, the following points were noted. The ratio of high grade tuna is still low with A grade composed of 25% only. A high degree of deterioration of tuna is seen resulting from formation of YAKE or Burnt Tuna Syndrome (figure 1). YAKE is not scientifically defined as the judgment of YAKE depends on the viewpoint of a person and is subjective. YAKE formation is indicated by white or brown colour of meat; easy to break fish meat due to low moisture and elasticity; acidic taste of meat; and unpleasant odour. For the purpose of this study, YAKE formation can be defined as lowering quality of fish meat by loss of red colour, elasticity and moisture.

Figure 1: YAKE formation in yellowfin tuna deteriorating the quality of fish

Any issues in tuna handling on deck and preserving in cold storage were not found during the on board survey. However, it is known that easy deterioration of fish quality is possible with the passage of time. The appearance of YAKE is affected by the core temperature of the fish. At the time of on board survey, yellowfin tuna core temperatures were 31 to 32°C after the removal of inner gut and gill. Six hours later core temperature of the fish meat was cooled to 8.6°C. From this result, it was very difficult to determine the appearance of YAKE on fish meat.

Based on the preliminary study results, several interventions to improve yellowfin tuna quality were proposed that involves improved handling and preservation methods. This includes:

- Modification of Ice box by re-design of the cooler box with a thicker insulation and compartmentalization for quick cooling and good preservation of fish. Effectiveness of the cooling will be examined by comparing with that of a non-modified box and by determining the varying fish quality in terms of grade at the time of landing. The fish from the modified box and unmodified box will be identified individually by tagging.
- The utilization of tuna electric shocker to prevent rising of the core temperature of the fish due to violent movement of the tuna in and out of the water.
- Reducing damage to fish on deck by using sponge mat during the handling, bleeding and removing of gut.
- Destroy the nerve located in tuna head and stop the violent movements, then putting in a wire from head through neural tube to the end of tube for stopping of fish movement completely.
- Used of chilled sea water and Irabu method for improving preservation conditions

2 Monitoring and Data Collection

2.1 Monitoring Observations

Project area: across Maldives
Fishing boat: MV. MAGLAS, NABEELA
Period of Monitoring: 01 year
Total no of Observations: 05
Team:

JICA expert, Fishing Technical, Mr. Morimitsu Ritsuo
Supervisor/Administrator, Dr Shazla Mohamed, The Maldives National University
Research Assistant, Mr Ibrahim Fikry, The Maldives National University
Observer, Mr Ahsan Mohamed, Ministry of Fisheries and Agriculture

Observation trips were conducted from February 2016 to February 2017 at different locations of the country. Observation dates and other relevant information regarding the observation trips are summarized in Table 1.

Table 1: Observation Schedule Details

#	Date	Observed by	Boat	Notes
1	October 2015	Morimitsui Ritsuo	Maglas	Trial Operation
2	6-18th Feb 2016	Ahsan Mohamed	Maglas	Location: GAf. Atoll , GDh. Atoll, Laam Atoll, Tha. Atoll, and Meem Atoll

3	11-17th Nov 2016	Ahsan Mohamed	Nabeela	Fishing operation was for 11 days from 12-22nd Nov 2016
4	25-30th Nov 2016	Morimitsu Ritsuo	Nabeela	Fishing operation was for 13 days from 25th Nov to 7th Dec 2016
5	6-19th Jan 2017	Ahsan Mohamed	Nabeela	Fishing operation was for 14 days from 6th to 19th Jan 2017
6	8-14th Feb 2017	Morimitsu Ritsuo	Nabeela	Fishing operation was for 14 days from 8th to 22th Feb 2017

Tuna caught for study purpose during observation trips were handled and preserved using one of the following methods:

1. Standard method with iced seawater (control method): postharvest handling involves instant kill by hitting the head of the fish, extraction of gills and guts and extraction of blood. Iced sea water was used for fish preservation in cooler box.

2. Irabu Yake Prevention method (test method): post-harvest handling in this method involves transferring fish while still alive to iced water for an hour. This is followed by extraction of gills and guts and extraction of blood. In this method too iced sea water is used for fish preservation (refer to the "Box" below).

Box: The "Irabu method" for Yake prevention

Yake is a phenomenon of deteriorating tuna meat (it looks like burned meat), which appears when the inner body temperature of tuna elevates a lot after strenuous movements made during the catch. It happens frequently in high water temperature areas. The problem of Yake has been a critical issue for long in Maldives since fish with Yake commands very low prices or is even rejected by the processing companies.

The same problem occurs in Okinawa, Japan, under similar sea and environment conditions; there, the Irabu Fisheries Cooperative Association developed a Yake prevention method named the "Irabu method". This method is quite unique as compared to the traditional one: the fish is not killed after it is caught and is directly placed into cold water so that the inner body temperature of the fish cools down through natural gill respiration and blood circulation. The Okinawa Fisheries Research Center verified the effectiveness of "Irabu method", as documented in publications in 2002.

Fish handled and preserved with the standard yellowfin tuna handling and storage method (figure 2) in Maldives were treated as follows:

- Tuna was landed on the deck using gaff
- Fish was hit on the head with a club (stunning)
- gills and inner guts were immediately removed
- Abdominal cavity and stomach was cleaned with sea water
- Fish were transferred to cooler box with slurry ice made from sea water

- Hooking fish by gaff

- Stunning head by club

- Removing gill and inner guts

- Preserve in cooler box with ice

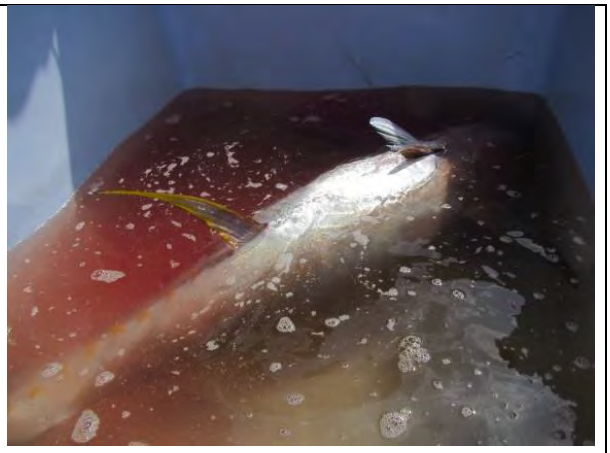
Figure 2：Yellowfin tuna handling and preservation by the standard method used in Maldives

Fish preserved with the Irabu Yake prevention method (Figure 3) was treated as follows:

- Cold water at 10-15℃ was prepared in a pre-cooling cooler box
- The fish was transferred to the cold water without any mortal damage while still alive
- Fish was kept for pre-cooling in the cold water but letting it soak for 50~60 minutes to cool down fish meat

- Fish is removed from the cold water, gill and guts removed and abdominal cavity cleaned
- Fish is then preserved in brine ice slurry in a cooler box

- Cold water preparation work



- A scene of live yellowfin tuna in pre-cooling cooler box

- Cleaning abdominal cavity of fish after removing gill and inner gut

- Preservation in the brine ice water

Figure 3: Yellowfin tuna handling and preservation by Irabu Yake Prevention Method

Specific information related to handling and storage was recorded on the data recording sheet (Appendix 1) for each fish observed. The necessary information was collected and recorded:

- Date and time of catch
- Variety of fish and estimated weight
- Seawater temperature (beginning and end of daily operation)

After the observation trip, the study vessel returned to Ensis Fish processing factory at Hulhumale'. The tuna fish was unloaded and graded accordingly as per the grading system applied for tuna exported from Maldives. The caught fishes are graded by empirical rule of grader as none written standard roles where fish are given grades from

A+ to C and reject, R based on the quality. To grade the fresh fish, a centre plug is extracted from the middle of the fish using a sampler. The samples are then placed in a white background and graded by visual observation using natural light. The information was recorded in the data recording sheet.

Data from the observation trips were input in to a data base. Tuna grading data of fish treated with the proposed handling methods of Irabu YAKE Prevention Method and existing control method was compared.

2.2 Qualitative Information on Opinions of Fishers

Qualitative information regarding the effectiveness of the modified method and overall opinion on the modifications was obtained through a survey conducted among the fishers onboard the study vessel NABEELA. An open ended survey questionnaire with a rating for overall impression of the use of Irabu method and other modifications was designed and administered to a total of 8 fishers. This included information regarding the following:

- General impression of the project including used of modified equipment such as cooler box and electric shocker, methods and monitoring activities
- Overall effectiveness of Irabu method on improvement of yellowfin tuna quality
- effectiveness of newly introduced double insulated cooler box including size, cooling capacity and feasibility
- additional recommendations for improvement of yellowfin tuna quality

The questionnaire is given in Appendix 2. Information from the survey was input into MS Excel. The method utilized for data analysis was content analysis which includes identifying major categories for the responses given by the fishers. Categories were generated inductively from the information provided.

3 Monitoring and Survey Results

3.1 Observation of Preservation Methods

A total of 182 tuna fish caught during all observation trips were used for the study of which 41 were treated with the Irabu method while the rest was all handled and stored using the standard control method.

Table 2: Quality grading data for yellowfin tuna treated with Irabu and control method in all observation trips

		Grading Category					
		A+	A	B+	B	C	R
Irabu	Nov 2016		3	3	2		
	Dec 2016			2	11		
	Jan 2017		5	3	7		
	Feb 2017		1	2	2		
	total	0	9	10	22	0	0
Control	Nov 2016		8	3	13	5	5
	Dec 2016	2	7	6	19	14	9
	Jan 2017		3	0	23	1	9
	Feb 2017		5	1	5	2	1
	total	2	23	10	60	22	24

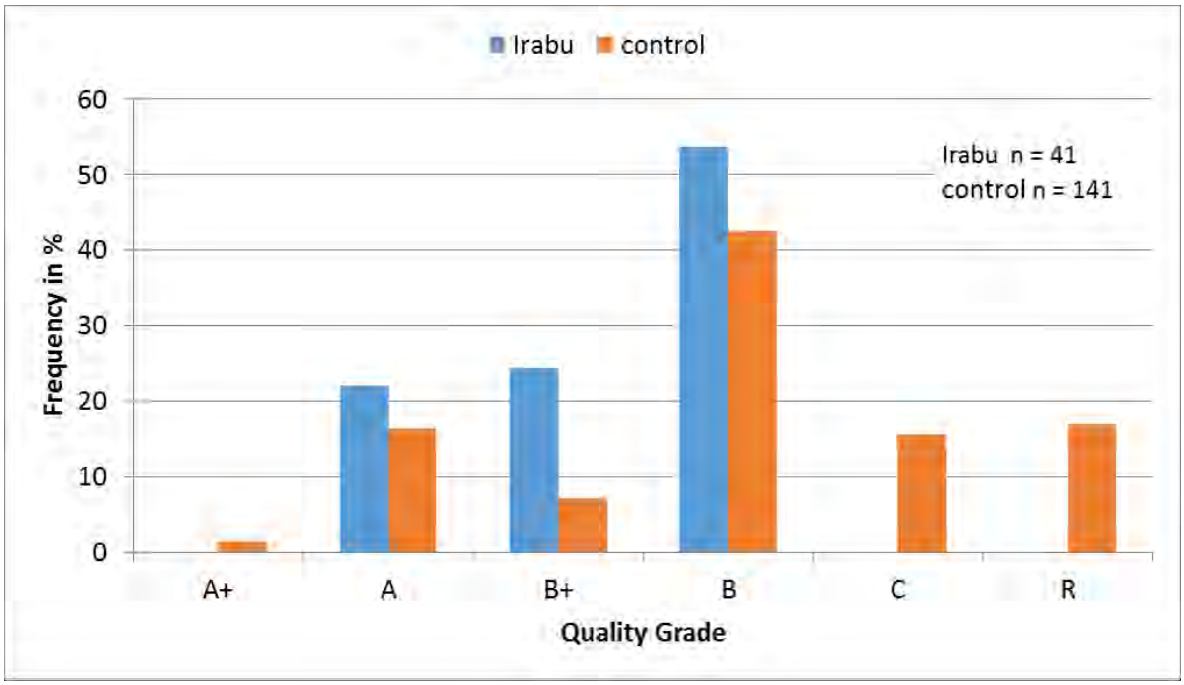


Figure 4 Comparison of the quality of yellowfin treated with Irabu and control method

The data (Table 2 & Figure 4) suggest that all tuna that is 100% tuna treated using Irabu method are either B grade or above although none of the fish were of the highest A+ category. Also the quality grading for the Irabu treated fish indicates a similar percentage distribution among A grade (22%) and B+ grade (24%) while more fish displays B grade (54%). It should be noted that none of the tuna treated with this method falls in the C grade category or below which are rejects.

In contrast, fish preserved using the standard control method shows varying quality distributed across all categories from A+ to Reject grade R. A total of 33% tuna treated with this method are either C grade or below of which 17% are rejects.

3.2 Opinion of Fishers

Information obtained from the survey questionnaire administered to eight fishers onboard the test vessel is reported. When asked to express their overall opinion of the newly introduced Irabu Yake prevention method, seven out of eight fishers gave a positive response quoting phrases such as “good” and “beneficial”. However, at the same time six of them stated that they did not notice any difference in quality of fish treated by this method.

Six fishers from test vessel Nabeela agreed that they have acquired new information or knowledge from this project while two of them did not agree. In response to the question regarding what is necessary for improvement of the quality of tuna in the future, all eight of them mentioned better quality ice. In addition, six of them also believes utilization of better quality ice boxes onboard will lead to improvement of the quality of tuna.

4 Discussion and Conclusions

This study is focused on enhancing the quality of hand line yellowfin tuna by introduction of improved handling and preservation methods specifically the Irabu Yake prevention method.

Based on the quantitative data from the observation trips, Irabu method clearly shows a positive impact on the quality of fish compared to the currently used standard method. This is evident from the fact that all tuna treated with Irabu method are B grade and above while none of the fish are C grade and below. However, tuna treated with the standard control method is of varying quality ranging from A+ to reject grade. Also approximately one third of the tuna treated with the control method are of low quality (C grade or rejects). Hence, this study confirms adoption of Irabu method by the fishing vessels of Maldives as an improved alternative to the currently used method could yield better quality yellowfin tuna leading to increased profit.

Deterioration of tuna quality as a result of Yake formation results from high body temperature of the fish, lactic acid production and proteolytic activity of the meat. Body

temperature of the tuna treated with Irabu method is rapidly lowered when fish caught is directly transferred to chill sea water while still alive. In addition to reduction in Yake formation, the rapid cooling witnessed in this method lowers other quality deterioration indicators such as lactic acid formation. In the standard method utilized in Maldives, tuna is killed and gutted before transfer to storage in chilled seawater, giving opportunity for increase of body temperature of the fish. This could lead to subsequent loss of quality by formation of Yake in the fish meat.

The increase in the number of A+ and/or A grade tuna with the Irabu treatment is lower than expected (Standard method: 17%, Irabu method: 22%). An increase in number of superior quality fish was anticipated with the newly introduced methods and improvements. This could be the result of small sample size used especially for Irabu treatment due to limited number of observation trips and unfavorable weather. Hence, it is recommended to continue data collection for a longer period of time. The other drawback was the failure to verify other intervention methods planned initially such as the modified cooler box and tuna electric shocker.

Most Fishers suggest introduction of better quality ice boxes as a major step towards improvement of the quality of yellowfin tuna caught. The use of modified cooler box with a higher insulation could be one of the main approaches in this regard. Effectiveness of the new modified ice box with thicker insulation and compartmentalization for quick cooling was experimented onboard by comparison against standard cool box although it was not part of the observations. Two modified ice boxes with 1.5 times thicker insulation than the normal ones, one with partition and other with no partitions was used. The preserving capability of the ice boxes were determined by visually measuring the ice melting speed of the cooler boxes. It was therefore verified that the modified cooler box have higher preserving capability than the generally used model.

During the phase of the project and especially the monitoring observations, there had been several issues which resulted in delays and inconsistent results. Observation vessels were changed three times during the course of this study due to low catch and other reasons and monitoring surveys were halted for 11 months before any concrete data was collected. Also communication between the first vessel and monitoring team was often difficult. It should be highlighted that fishers lacked motivation and support for the survey since there was no incentive or direct benefit for them. This could also be a major reason for encountering problems in introducing other interventions such as modified cooler boxes in a timely manner. Hence, due consideration has to be given when selecting a vessel for future studies. Initial delays also occurred due to time spent on nominating observers and unavailability of qualified people to go onboard for longer period of 1 or 2 weeks. There were also delays due to lack of coordination between monitoring team, observer and the vessel.

Recommendations

- It is necessary to extend the Irabu Yake prevention method together with the modified ice boxes to compare and observe the improvement in yellowfin tuna quality. Hence, it is recommended to continue the study with these modifications

to develop a more effective treatment method.

- It may be also useful to introduce other interventions that were initially planned such as the use of tuna shocker, spearing and use of sponge mats for fish landing. It is recommended to continue the study to compare these modifications with the control method.

- Tuna treated with the control method in the current study is more than three times the number of tuna treated with Irabu method. It is important to have similar distribution for each of the treatment methods in any future studies and to maintain all external parameters consistent.

- It is recommended to select a study vessel after careful consideration for improved utilization of time and resources and a successful observation study. If required, it may be useful to give incentives for fishers for them to be motivated and more willing to participate in the study. Also observations should be scheduled to coincide with periods when fish is abundant.

In conclusion, it is evident from the observation data that Irabu Yake prevention method had a positive effect on the quality of yellowfin tuna although the impact is lower than expected. This could be due to several reasons including failure to introduce other interventions such as modified cooler boxes and inadequate amount of data. Hence, it necessary to continue data collection with additional modifications and other improvements recommended.

Appendix1 Yellowfin Tuna Fishing Log Sheet

Name of Vessel :		Name of Captain :		Weather condition: ☐sunny ☐cloudy ☐rain	
Recorder :		Fishing Area		Swell of the ocean: ☐low ☐moderate ☐heavy	
Type of bait fish:		Sea temperature : ℃		Wind temperature: ℃	
Departure date :		Time:	Return date :		Time:

	No.	Weight (by eyes)	Catching time (from hooking to landing on boat)	Fish handling time on deck	Ice status in tank	Temperature of flesh in center part (landing time at boat and landing)				Grading by ENSIS
Modified method (yellow tag)	1				☐sufficient ☐insufficient	Time on boat Flesh ℃		Time at ENSIS Flesh ℃		A B C D
	2				☐sufficient ☐insufficient	Time on boat Flesh ℃		Time at ENSIS Flesh ℃		A B C D
	3				☐sufficient ☐insufficient	Time on boat Flesh ℃		Time at ENSIS Flesh ℃		A B C D
	4				☐sufficient ☐insufficient	Time on boat Flesh ℃		Time at ENSIS Flesh ℃		A B C D
	5				☐sufficient ☐insufficient	Time on boat Flesh ℃		Time at ENSIS Flesh ℃		A B C D
Local method (white tag)	1				☐sufficient ☐insufficient	Time on boat Flesh ℃		Time at ENSIS Flesh ℃		A B C D
	2				☐sufficient ☐insufficient	Time on boat Flesh ℃		Time at ENSIS Flesh ℃		A B C D
	3				☐sufficient ☐insufficient	Time on boat Flesh ℃		Time at ENSIS Flesh ℃		A B C D
	4				☐sufficient ☐insufficient	Time on boat Flesh ℃		Time at ENSIS Flesh ℃		A B C D
	5				☐sufficient ☐insufficient	Time on boat Flesh ℃		Time at ENSIS Flesh ℃		A B C D
						Log keeper's signature:				

Appendix 2 Opinion of Fishers Survey Questionnaire

1 The impression of the pilot project.

Please let me know the impression of the entire this pilot project. (Please select or describe)		Very good	Good	Ordinarily	bad	very bad	Total
①	Is it useful of this trial operation for the improvement of the quality of tuna ?	1	3	4			8
②	How is the preserving efficiency of newly modified cooler box ?	5	2	1			8
③	How was the monitoring data collection method ?	6	2				8
④	How was the tuna electric shocker ?	6	2				8

2 Please describe your impression of the [Irabu yake prevention method] ?

1.This way of storing/preserving tuna on-board is a beneficial method. 2.Good. But did not notice any improvements in quality 3.This method is good method, but did not notice a change in quality of fish 4.Good. But did not notice any improvements in quality 5.This way of storing/preserving tuna on-board is a good method 6.This way of storing/preserving tuna on-board is a good method, but did notice a change in quality of fish 7.Did not notice a difference

3 Did you get any new information or knowledge from this project ?

Yes	No
6	2

In case of [Yes], please describe it.

1.Gained more/different experience 2.Gained more experience and learned new things. Observed electric shocker is very efficient 3.Gained new experience 4.Gained new fishery experience 5.Gained new fishery experience and knowledge 6.Gained new fishery experience and knowledge

4 Is it possible to accept the modified cooler box to other dhoni, do you think ?

Yes	No
6	2

5 What is necessary for the improvement of the quality of tuna fish in the future, do you think?

1.Better quality ice and better quality coolbox 2.Better quality cool boxes and better quality ice 3.good quality coolbox and good quality ice 4.Acess to good quality ice 5.Access to good quality ice 6.Access to good quality ice and good quality cool box 7.Better quality ice and better quality coolbox

PP-3. Preliminary resource survey on availability of deep-sea resources

1) Final report of Pilot Project 3: Preliminary resource survey on availability of deep-sea resources

Final repot of Pilot Project3

- Preliminary resource survey on availability of deep-sea resources -

MASPLAN

The Republic of Maldives

Project for the Formulation of Master Plan

for Sustainable Fisheries

MoFA/ MRC:
Abdulla Jaufar, Mohamed Azheem, Ahsan Mohamed (MoFA)
Riyaz Jauhary, Ismail Haleem, Mohamed Ahusan, Islam Fahmeeda (MRC)

JICA Experts:
Motoki Fujii (Fishing Technology)
Yoshiki Hino (Livelihood improvement)

Contents

1. Background

The fishery sector of the Maldives is so far extremely dependent on skipjack and other tuna species. Therefore the fishery diversification is an urgent issue taking account of the decline of the catch of skipjack tuna. Deep-sea resources have not been assessed sufficiently in terms of species and quantities available, due to the absence of fishery development in this field. This situation also applies to the squid resources, as there is no squid fishery in Maldives except for game fishing. Squid represents a potential fishery resource for the future since its lifespan is estimated at only one year and the re-stocking is quite high. It is known that the Diamondback squid (DBS) *Tysanoteuthis rhombus* inhabits all around the globe in tropical and sub-tropical oceanic waters. Catches of DBS have been reported not only in Okinawa, Japan where the DBS fishery has been developed but also in the South-Pacific and the Caribbean seas. The Maldivian waters are also presumed to have a potential of DBS resources since there were some floating egg mass found by researchers and fishers.

On the other hand, a high demand for high quality seafood products in the Maldives is expected, taking into account the remarkable growth of the tourism industry in the country and the global Japanese food boom. If resources of demersal fin-fishes and DBS are developed in the Maldives, it would contribute to diversification of the fishery products targeted by the resorts and foreign markets.

It is also important for fishers to develop unutilized fishery resources from the point of view of additional income sources. To cope with the changes in the location of the fishing grounds and in the quantities caught linked to global climate change, and to address the fluctuation of the seasonal catch, the new potential fisheries are highly expected to improve fishers' life as long as their adequate management is ensured.

The importance of Pilot Project 3 (PP.3) was confirmed through the problem analysis of the Oceanic fisheries SSWG and designed as an additional PP based on the request of MoFA.

2. Research on the presence of DBS egg mass in Maldivian water

The information on the presence of DBS egg mass in other countries indicates that the adult squids are present near the locations where the egg masses are found.

Through the preliminary survey conducted in October 2015, sightings of DBS egg mass (Figure 1) were confirmed and therefore the existence of DBS in Maldives was clarified. In November 2015, a survey questionnaire form which permitted users to respond through internet was designed and sent by e-mail to most of the resorts in the country. In addition, the form was posted on the Facebook page for marine biologists working in Maldives, in order to collect information from a wider range of the population. Interview survey for fishers was conducted

three times in February and March 2016 (Figure 2).

Through these surveys, 41 cases of DBS egg mass sightings were reported. Based on the collected information, monthly variation and locations of the sightings were analyzed. In addition, the seasonal wind direction and ocean current in Maldives were examined. Results of the analysis showed a high possibility of DBS spawning in the coastal areas of Maldives from November to February; the spawning area is assumed to be around the whole country. The results of the analysis were presented in the report on the "Expected deep-sea fishery resources distribution (DBS)" in November 2016 (see Attachment 1).

Figure 1. Egg mass of DBS
Source: Nimoho *et al.* (2014)

Photo 2. Interview survey at Malé fishing port (25 Feb 2016)

3. Preparation work of necessary fishing gear and equipment

The necessary equipment for the deep-sea fishery resources survey was procured in Japan in August 2016 and was transported to Maldives in September 2016. The installation of the line hauler onto the survey vessel, "Reendhoouraha", was completed during the assignment period of Mr. Fujii, a Fishing Technology Expert, in September 2016. During his assignment he provided lectures on DBS and bottom-set vertical longline (BVLL) fisheries, and transferred technology on the construction method of DBS fishing gear and BVLL fishing gear to the captain and the crews of the vessel (Figure 3). However, the vessel "Reendhoouraha" accidentally ran aground on 1st of Nov. 2016; it was severely damaged on the propeller, the propeller shaft, the keel and the rudder holder, and several weeks were required for the repair works on the dry dock. As a result, a vessel of the same type, the "Loabodu" (Figure 4), which was used by MoFA for FAD deployment, was selected hastily as a substitute to "Reendhoouraha" to carry out the resource survey in Nov. 2016. After Mr. Fujii's arrival, the line hauler was transferred from Reendhoouraha to Loabodu, and he conducted technology transfer for the captain and the crews of the substitute vessel "Loabodu".

In the resource survey implemented in February-March 2017, Reendhoouraha was used as a research vessel. Prior to the implementation of the resource survey, checking of the fishing

gear and the replacement of the line hauler were conducted. The spare fishing gear was also constructed on board as necessary. A series of activities were conducted as planned.

Attachment 2 shows the list of fishing gear and equipment procured in Japan.

Figure 3. A scene of DBS gear construction practice

Figure 4. The resource survey vessel "Loabodu"

4. Deep-sea fishery resources survey (demersal fishes)

The resource survey was suspended in November 2016 as Loabodu was not equipped with an echo-sounder; it was carried out in February-March 2017 with Reendhouraha, with the proper echo-sounder of this vessel. A total of 8 operations were implemented on some banks in the deep-sea and reef edges, where the seabed is 150 - 400m in depth. It should be noted that the range of the echo-sounder was only around 100m, whereas this range should be 300m to offer optimal conditions. Accordingly, Mr. Fujii and MoFA staffs decided the survey points on the basis of nautical charts and electronic charts. The resource surveys were implemented from Feb. 12, 2016 to Mar. 1, 2017 at both east and west sides of north and central parts of Maldives. The details of the resource survey are shown in Table 1.

Table 1. Summary of deep-sea fishery resources survey (demersal fishes)
(Excluding shark and moray eel)

Date of operation	Time	Survey sea are		No. of catch
		Atoll	Coast	
12 Feb 2017	PM	North Male	East	0
14 Feb 2017	AM/ PM	South Male	East	0
15 Feb 2017	PM	Alifu Alifu	North west	0
21 Feb 2017	PM	Haa Dhaalu (Maamakunudhoo)	South West	5
22 Feb 2017	PM	Raa	East	1
26 Feb 2017	PM	Meemu	East	3
28 Feb 2017	AM	Dhaalu	West	5
1 Mar 2017	PM	Alifu Dhaalu	South	5

Among the 8 survey operations, there was no catch on the first 3 operations (Feb.12, 14, 15); for these operations, deep-sea banks had been chosen as fishing points but the fishing gear did not reach the bottom of the sea. Possible reasons for the failures were as follows, 1) the point where the fishing gear was set was out of the bank, 2) the bank did not actually exist since there are many cases where the seabed depth of the deep-sea areas shown on the electronic chart is not as accurate as that of the shallow areas. Thus, to increase the probability of catch, the survey points were changed to the reef-edge where the seabed falls down sharply. Through the resource survey, a total of 19 fishes of 14 fish species which have a high commercial value such as groupers, snappers etc. were caught (Figure 5, 6). Table 2 shows the demersal fish species caught by the resource survey and Figure 7 indicates the catch points of them.

The summary of survey results are indicated in Attachment 3.

Figure 5. A scene of resource survey

Figure 6. A harvest scene of demersal fishes

Table 2. Demersal fish species caught by the resource survey (D: depth)

Species	Place of catch	Species	Place of catch
 Serranidae (not specified)	West reef edge of Maamakunudhoo (Haa Dhaalu) D: 300m	 *Lethrinus conchyliatus*	East of Veyvah, Meemu D: 200m
 *Epinephelus chlorostigma*	East of Vayah Meemu D: 200m 3NM SW of Hulhudheli, Dhaalu D: 300m	 *Lethrinus microdon*	East of Dhuvaafaru reef in Raa D: 200m
 *Epinephelus miliaris*	South of Fenfushi, Alifu Dhaalu D: 300m	 *Etelis carbunculus* or *E. coruscans*	3NM SW of Hulhudheli, Dhaalu D: 300m
 *Epinephelus areolatus*	South of Fenfushi, Alifu Dhaalu D: 300m	 *Macolor macularis* or *M. niger*	West reef edge of Maamakunudhoo (Haa Dhaalu) D: 300m
 *Pristipomoides filamentos*	West reef edge of Maamakunudhoo (Haa Dhaalu) D: 300m	 *Aphareus rutilans*	West reef edge of Maamakunudhoo (Haa Dhaalu) D: 300m 3NM SW of Hulhudheli, Dhaalu D: 300m, 150m
 *Pristipomoides auricilla*	East of Veyvah Meemu D: 300m South of Fenfushi, Alifu Dhaalu (2 fishes) D: 300m	 *Pinjalo lewisi*	South of Fenfushi, Alifu Dhaalu D: 300m
 *Pristipomoides* sp.	3NM SW of Hulhudheli, Dhaalu D: 300m	 *Wattsi mossambico*	West reef edge of Maamakunudhoo (Haa Dhaalu) D: 300m

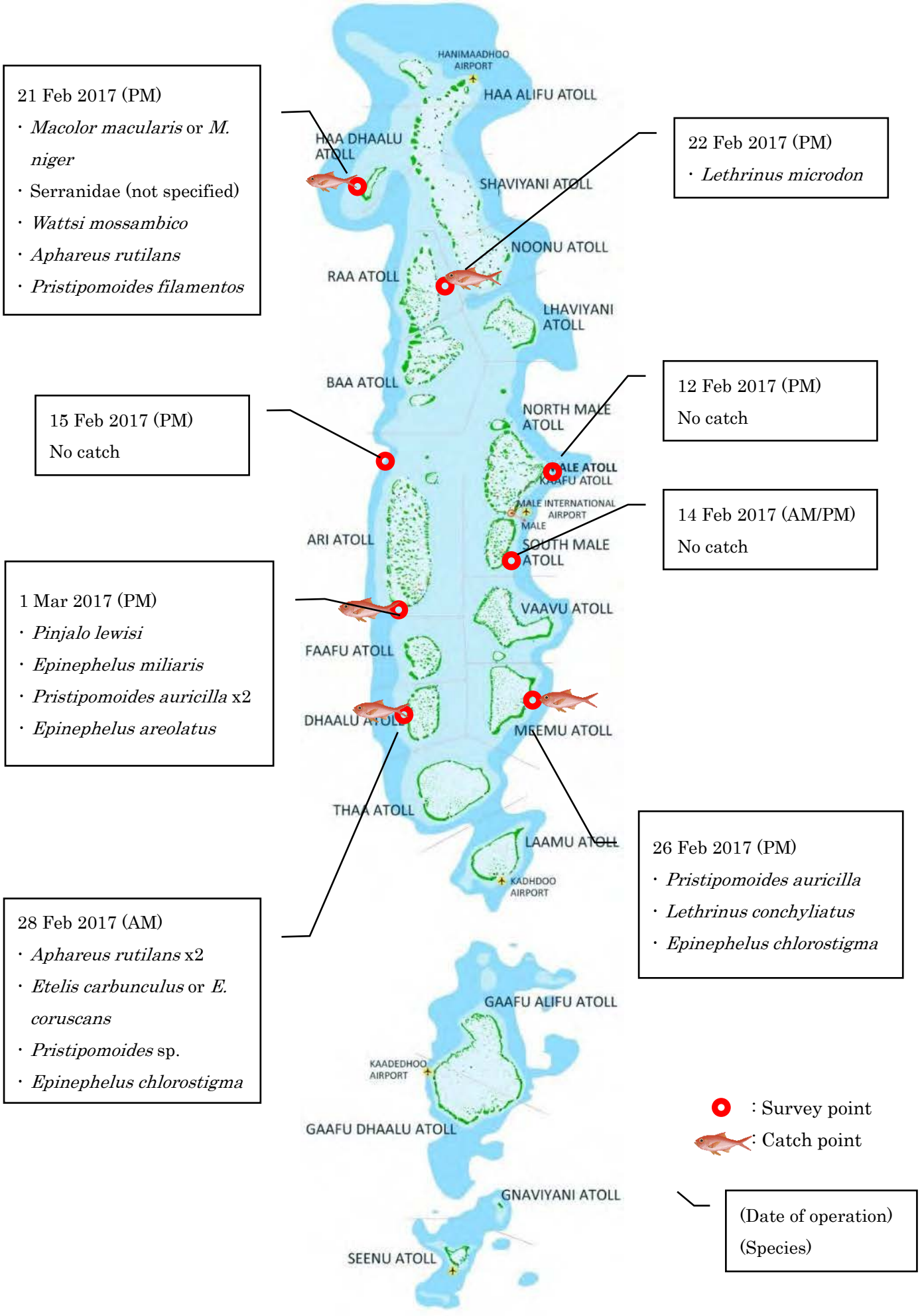


Figure 7. Location of deep-sea fishery resource survey (demersal fishes) and catch points

5. DBS resource survey

The resource survey consists of 5 or 6 days-trip (including travel days) and was implemented 5 times in total: 2 resource surveys were implemented in November 2016 and 3 resource surveys were implemented in February-March 2017.

The survey area in November 2016 was selected based on the report on the "expected deep-sea fishery resources distribution (DBS)". The Central Eastern and the North-eastern coastal areas in Maldives were prioritized for the resource survey in November 2016. The operations were conducted in 9 areas, where the 2,000m contour line forms an embayed-shape, in order to avoid strong ocean currents occurring in particular in sea channels. Furthermore, in the resource survey of February-March 2017, the survey areas were expanded to the west side and south-central part of Maldives in addition to where the resource survey was implemented in November 2016. The table 3 shows the results of the 5 resource surveys.

Table 3. Summary of results of DBS resources survey

No. of Survey	No. of Ope	Date of operation	Time	Survey area		No. of catch	Remark
				Atoll	Coastal		
1st survey	①	14 Nov 2016	AM	North Male	East	3	
	②	14 Nov 2016	PM	North Male	East	0	
	③	15 Nov 2016	AM	North Male	East	2	
	④	16 Nov 2016	AM	Vaavu	East	0	
	⑤	16 Nov 2016	PM	South Male	East	3	
	⑥	17 Nov 2016	AM	North Male	East	2	Same point①
2nd survey	⑦	20 Nov 2016	AM	Lhaviyani	North east	6	
	⑧	21 Nov 2016	AM	Shaviyani	East	0	
	⑨	21 Nov 2016	PM	Noonu	North east	1	
	⑩	22 Nov 2016	AM	Noonu	East	2	
	⑪	23 Nov 2016	AM	Noonu	East	1	Same point⑩
3rd survey	⑫	12 Feb 2017	AM	North Male	East	4	Same point①
	⑬	13 Feb 2017	AM	North Male	East	2	Same point③
	⑭	14 Feb 2017	AM	South Male	East	1	Same point⑤
	⑮	15 Feb 2017	AM	Alifu Alifu	North west	0	
	⑯	15 Feb 2017	PM	Alifu Alifu	North west	0	
4th survey	⑰	19 Feb 2017	AM/ PM	Lhaviyani	North east	4	Same point⑦
	⑱	20 Feb 2017	AM	Noonu	East	2	Same point⑩
	⑲	21 Feb 2017	AM	Raa	West	17	

	⑳	22 Feb 2017	AM	Shaviyani	West	1	
5th survey	㉑	26 Feb 2017	AM	Thaa	East	2	
	㉒	27 Feb 2017	AM	Meemu	South east	3	
	㉓	28 Feb 2017	AM/ PM	Dhaalu	West	0	
	㉔	1 Mar 2017	AM	Alifu Dhaalu	West	3	
					Total	59	

24 operations were done, and a total of 59 individuals of DBS (500.5kg) were caught (Figure 8, 9). This was the first official record of DBS catch in Maldives waters (Reference: Cruise Report "Dr. Fridtjof Nansen" - Survey of the Abundance and Distribution of the Fish Resources in the Coastal Waters off Maldives - 17-28 August 1983). The sites where DBS were caught are approximately 5-15 nm of the atolls, with a water depth of 1,500 to 2,000 m (NB: the length of the vertical fishing line is 500 m only) The sighting points of DBS egg mass and big squid carcass" and "DBS catch areas" were compiled and are shown in the following Figure 10.

Figure 8. A harvest scene of DBS

Figure 9. First catch of DBS in Maldives

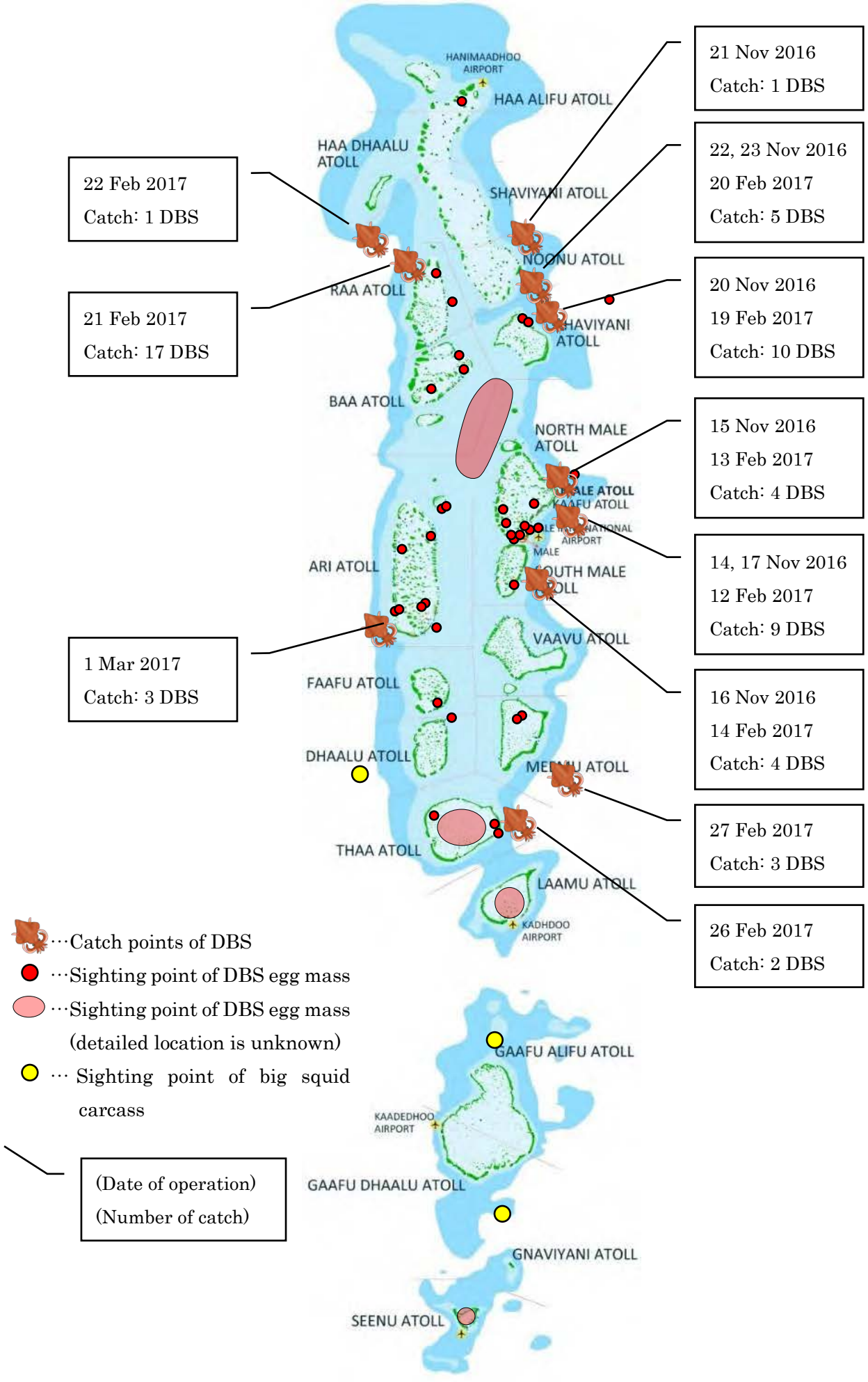


Figure 10. Sighting points of DBS egg mass and big squid carcass, and DBS catch areas

The range of mantle length of the 20 DBS caught in November 2016 was 35~71cm (weight range: 1.60~11.65 kg) and the range of the 39 DBS caught in February and March 2017 was 46～82cm (weight range: 4.0kg～16.8kg). In overall, the DBS caught in February-March were larger than the ones caught in November (Figure 11).

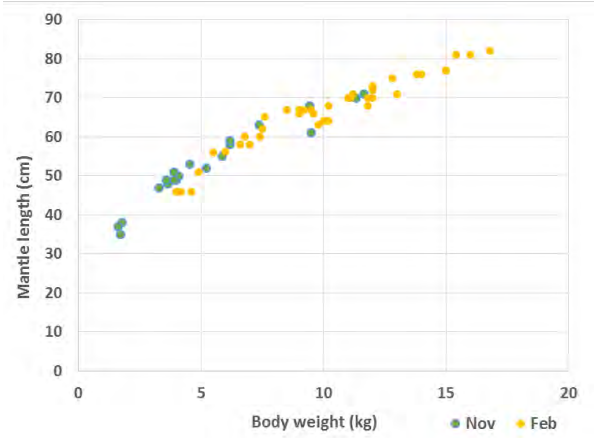


Figure 11. Relation between mantle length and body weight of DBS caught in November 2016 and February-March 2017

The sex ratio of the 20 DBS caught in November 2016 was 90% male and 10% female, which of the 39 DBS caught in February-March 2017 was approximately 60% male and 40% female. The average gonad weight of the 18 male DBS caught in November 2016 was 20.8g (4 - 46g) and that of the 23 male DBS caught in February-March 2017 was 42.6g (10 - 70g). It is presumed that the male DBS mature further from November to February-March. The average gonad weight of the 2 female DBS caught in November 2016 was 270.0g (60 - 480g) and that of the 16 female DBS caught in February-March 2017 was 330.0g (75 - 580g). Figure 12 and 13 are the phots of DBS gonad.

Figure 12. Gonad of male DBS

Figure 13. Gonad of female DBS

It appears that there is a correlation between the mantle length and the gonad weight of both male and female (Figure 14). In particular, the gonad weight of female increases sharply after their mantle length reaches 60cm.

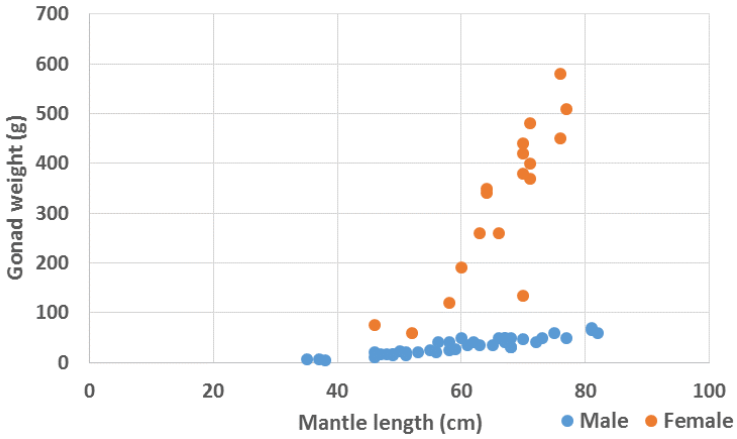


Figure 14. Relation between mantle length and gonad weight of DBS (Male: blue, Female: orange)

The primary processing of the DBS caught was conducted in collaboration with MIFCO processing facility in Kandu Oiy Giri (KOG), and DBS were processed into frozen vacuumed packages and frozen roll. The DBS products were preserved in a freezer at KOG. 383.25kg in total were produced from 500.5kg, so the yield ratio of DBS was 76.6%.

The summary of survey results are indicated in Attachment 4.

6. Additional activity

MoFA conducted a media release about the first catch of DBS in November 2016 (figure 15). Mr. Fujii (JICA expert) and Mr. Jaufar (MoFA) were interviewed by reporters and they explained about the ecology of DBS and the processing method.

Figure 15. A scene of media release for the first DBS catch in Maldives

In addition, after the resource survey was completed, the project hold a DBS tasting session in collaboration with Chefs Guild of Maldives on March 12, 2017: a Maldivian chef working in the Bandos resort as a Japanese food chef prepared hand-rolled Sushi, Sashimi, Japanese curry, Sushi rolls and Chirashi sushi with DBS and served them to the participants. In this session, Mr. Fujii and Mr. Jaufar demonstrated the primary processing of DBS. 50 participants including the Minister of MoFA, staff of the Embassy of Japan, JICA Maldives staff and some students of the Faculty of Tourism gathered to the venue of the Faculty of Hospitality and Tourism Studies in the Maldives National University (Figure 16, 17).

Figure 16. DBS hand-rolled sushi prepared by Maldivian chef

Figure 17. Demonstration of primary processing

7. Strengths and weaknesses found upon implementation

7.1 Strengths

a. It was relatively easy for MoFA/MRC staff and crews who have a basic knowledge of fishery to understand the method of constructing the fishing gear due to the simple structure of the BVLL and DBS fishing gear and the simple fishing method; therefore, the technology transfer was conducted smoothly.

b. The sea condition during the 2 weeks of the survey in November 2016 was quite calm; hence the resource survey was implemented smoothly. Regarding the 3 weeks resource survey held in February-March 2017, the operation was implemented under relatively good conditions (rough sea was experienced during 1 week only) and the resource survey was implemented smoothly.

c. This DBS catch was the first official record in Maldives, therefore, the public relations activities were conducted positively by MoFA and the media, in particular for the tasting session. Consequently, this PP activity got much attention from various stakeholders.

d. In recent years, the tourism industry has been developing remarkably in the Maldives. High demand for high quality seafood produced in Maldives is expected. Under such circumstances, the output of this PP is likely to rise continuous interest from the Chefs Guild of Maldives and some resort restaurants.

e. The support from MIFCO in terms of allocation of a survey vessel, assignment of crew and use of their processing facility (KOG) represented a substantial contribution for the implementation of the PP.

7.2 Weaknesses found upon implementation

a. The catch of DBS was a major success and the deep-sea fishery resource survey (demersal fishes) also showed good results. However, the reef species caught during the survey were the same species currently caught by fishers on the reef; they might therefore not be motivated to go further offshore.

b. The total length of both vessels used for the resource survey and operated by MIFCO to deploy FAD and carry material, is around 85 feet. In order to disseminate these fishing technologies, smaller boats may be more adequate in technical and economic conditions to suit.

c. The echo-sounder was not utilized in all the resource surveys to look for deep-sea fishery resources (demersal fishes). It was not efficient to use only nautical charts and electronic charts to select the fishing points. The installation of a high performance echo-sounder onto the vessels is therefore important.

8. Justification of proposed projects related to the pilot project

Development of new deep sea fisheries (DBS and other fishes)

This project aims to promote the DBS fishery and deep-sea fishery after the MASPLAN PP succeeded in catching such resources in the coastal areas of Maldives. In the PP, the installation of fishing gear and the technology transfer to the C/Ps were achieved. Furthermore, the first official record of DBS catch materialized and the catch of some demersal fishes with high commercial value was achieved in coastal areas where the seabed depth is 150-400m. These outputs are assessed as a successful initial step for the development of new deep-sea fishery resources.

However, the overall ecological information on DBS is insufficient in the Maldives, is limited to the results of the PP outputs only. In order to collect information on the seasonal change of catch volume and individual size of DBS, the resource survey should be implemented during the season of the year not covered by the PP; likewise, for the targeted demersal fishes, the resource survey should be implemented in the areas not covered by the PP. Therefore Output 1 of the proposed project, “Availability of untapped deep-sea resources is demonstrated by MASPLAN preliminary resource survey and its continual survey“, will implement the resource survey on a continuous basis in order to grasp more detailed distribution of deep-sea fishery resources in the Maldivian sea. The following 3 activities are set to achieve Output1: Activity 1. “1-1 Obtain basic information for planning of the untapped deep-sea fishery resources survey.”, “1-2 Plan and prepare the necessary fishing gears and equipment for the resource survey”, “1-3 Implement the resource survey on the distribution states of unutilized deep-sea fishery resources”.

A great concern on the price and quantity of supply of the targeted species has been raised by those concerned with the PP, i.e. MIFCO and the Chef guild of Maldives. The most important factor is whether the new fishery can materialize as a business or not; the information about the initial costs, the operation costs and the selling price upon landing are important to assess the viability of these new fisheries. As Output 2 of this project, a feasibility study will be carried out, including a marketing survey with indications on demand volume and prices of unutilized resources, for both domestic and international. The activities are "2-1 Carry out market researches on demand and prices etc. on local and international markets ", "2-2 Analyze feasibility depending on the potential catch quota and number of operating fishing boats", "2-3 Consolidate the results into the feasibility study report".

Adequate fishery management is important for sustainable use of fishery resources, in particular for the use of unutilized fishery resources. Based on the survey results of Output 1 and referring to the fisheries management of other countries, the Total Allowable Catch (TAC), Individual Quota (IQ) and licensing system for each targeted species will be set up through a domestic institutional (Output 3). The activities are "3-1 Decide TAC for the target species", "3-2 Decide maximum number of licenses allowed", "3-3 Decide IQ for each license", "3-4 Establish a national regulation for the new deep sea fisheries".

In parallel with the above 3 outputs, it is important to disseminate these new fisheries to fishers (Output 4). Prior to this, the awareness activity plan and the technical training plan of the DBS fishery and deep-sea fishery (demersal fishes) will be established. Catching DBS has been a recognized success through the implementation of the PP; nevertheless, there is hardly any information about the price and demand volume. Hence, the DBS fishery and deep-sea fishery (demersal fishes) are still unknown fisheries for fishers and it is not easy for them to decide and enter into these new fisheries. As a concrete method to solve this issue, it is necessary for the fishers who are interested in these fisheries accompany the continuous resource survey and obtain the constructing technology of fishing gear and fishing method. Besides, sharing the results of the feasibility survey (Output 2) with fishers will be one of the proposed method. On the other hand, MoFA will establish the regulatory standards of this new fishery as per Output 3, and will issue the license for fishers who fulfill the required conditions. Moreover, to promote the entry to these fisheries, it is also expected that MoFA will establish the support system to procure the fishing gear and to conduct the technical training. The activities are as follows. "4-1 Plan awareness and training program for new deep-sea fishing method", "4-2 Hold awareness program for fishers on these new fisheries", "4-3 Implement training on fishing techniques and resource management targeted to interested fishers", "4-4 Support procurement and preparation of fishing gears and equipment", "4-5 Issue a license to fishers who meet the required conditions such as attendance to the training and preparation of the necessary gears and equipment".

This project consists of the above 4 outputs. The project period is set from October 2016 to 2022 (this project includes the activity period of the PP) and aims to issue the first license by 2020.

9. Concluding remarks

From a fishery diversification perspective, the development of deep-sea fishery (demersal fishes) and DBS resources may have further potential for the fisheries sector of the Maldives which is so far extremely dependent on tuna species. The importance of this PP was confirmed through the problem analysis in the oceanic fisheries SSWG and designed as an additional PP based on the request of MoFA. A great interest in the preliminary information surveys has been shown by the Maldivian side, and the resource survey in November 2016 brought significant results, specifically the first catch of DBS in Maldivian waters. Regarding the deep-sea fishery resource survey (demersal fishes), significant results were obtained in spite of some adverse conditions regarding sea condition and available equipment.

The inputs to the PP are divided into three, namely: 1) Personnel inputs for the basic information survey and resource survey, 2) Fishing gear and equipment for the resource survey and 3) Research vessel. Regarding 1), the input from the Japanese side was considered most efficiently done within the limited assignment period of the Japanese experts, also Maldivian side exerted maximum efforts to achieve the goal. Regarding 2), almost all equipment and fishing gears were procured in Japan and the procedure has been carried out as scheduled, without delay. Regarding 3), the PP used a vessel belonging to MIFCO for the resource survey. In spite of the accident Reendhoouraha, it is considered that MIFCO and MoFA made maximum efforts within their capacity, and the resource survey was carried out on schedule, without delay.

The MoFA and MRC staffs in charge made their best to carry out their duties (such as the implementation of DBS egg mass survey and the installation of fishing gear) with the limited human resources available and the assignment period. Furthermore, the hard work and team work by crews of Loabodu and Reendhoouraha ensured the smooth operation of resource survey. In addition, the primary processing and frozen storage in hygienic environment were implemented with close cooperation of MIFCO in its processing facility (KOG). All these combined efforts have been an important factor for the achievement of the PP.

However, the output of the PP is solely an entry to further fishing development. A lot of issue still need to be addressed, e.g. a yearly resource survey, market development, fishery resources management, awareness and training for fishers in order to achieve the fishing development in the context of sustainable development. To address these issues, a new project which includes the activities of the PP was proposed in the SFDPIS. It is expected that new fisheries will be established through the implementation of this project.

Attachment 1

Survey report of
“Expected deep-sea resources distribution
(Diamondback squid)”

Contents

1. Background of the survey

The Diamondback squid (DBS) inhabits all around the globe in tropical and sub-tropical oceanic water deeper than 400m and where the surface water temperature is above 20 degree C. It is known that the mantle size reaches 100 – 130cm and the weight reaches 24 – 30kg. Considering the fact that the life span of this squid is suggested to be only one year (Ando et al. 2004a), the high post-hatch growth rate of this squid is noteworthy.

In Japan, DBS is caught in Okinawa and Sanin region (Japan Sea side) and its tender meat is highly demandable in the Japanese market, as a fresh seafood product for Sushi. The value of the transaction of DBS is 700 – 1,000 yen/kg and DBS fishery is known to be profitable. But the resources development of DBS is not progressing very much on a global scale because the commercial fisheries of DBS are operated only in Japan and locally in Taiwan; in other words, it is believed that DBS resources are not fully utilized considering its estimated resource quantity. On the other hand, it can be said that the potential demand of DBS is increasing with the global Japanese food boom.

Even though it is expected that the distribution of DBS covers Maldives, the actual catch of DBS has not been confirmed yet. If the presence of DBS resources is confirmed in Maldives, the DBS exploitation may have potential from the standpoint of the diversification of fishery, as the fishery sector of Maldives is so far highly depending on the skipjack and tuna resources.

2. Survey purpose

This survey aims to confirm the presence of DBS resources in the coastal waters of Maldives and to estimate its spawning season and spawning ground in order to determine the resource survey schedule and area.

3. Survey method

This survey was implemented by using the 'Egg Trace Method' which is known to be effective to confirm the presence of DBS, its spawning area and period. This method utilizes the fact that the presence of DBS occurs near the sighting point of DBS egg mass, since the spawning period of DBS is known to be relatively short (around 5 -7days). Moreover, to estimate the spawning ground from the sighting point of egg mass, a survey on the sea current in the Indian Sea and the seasonal wind direction in Maldives was carried out.

3.1 Web-questionnaire/ Interview survey

DBS egg mass is translucent red and the structure is cylindrical with free-floating

characteristic. Owing to this characteristic, it is thought that the DBS egg mass has often been found by the recreational divers and fishers. Therefore, 3 survey methods, 1) Preliminary survey by Internet surfing and e-mail, 2) Web-questionnaire survey and 3) Interview survey were implemented to collect the information about DBS egg mass.

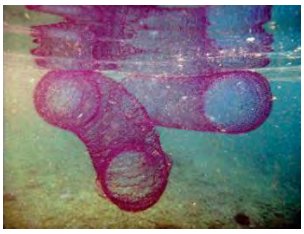


Photo 1. Egg mass of DBS
source: Nimoho et al. (2014)

(1) Preliminary survey

The information that indicates the presence of DBS egg mass in Maldives was collected by the retrieval keyword as 'Maldives', 'DBS egg mass', 'Diamondback squid' etc. through the internet. In case the date and the location of sighting was indefinite, it was cleared by an inquiry to the information providers.

(2) Web-questionnaire survey

A questionnaire was designed using a 'Google Form' which permits users to answer it on the Web; the form was sent to resorts across Maldives in November 2015. In addition, using Facebook as a common information sharing tool for Maldivians, the form was posted on the page for the marine scientists working in Maldives, including the diving instructors and marine biologists who were contracted by resort hotels. Furthermore, by sharing the posted form by MRC staff on the Facebook in February 2016, more information was collected from a wide range of population.

(3) Interview survey

The interview survey was implemented with fishers as there were many chances that they would see the egg mass during their fishing operation throughout Maldives. As a detailed method, the interviewer showed the picture of DBS egg mass to fishers; if fishers said they had seen some, the interviewer asked them the shape and color and judged if the sighted object is DBS egg mass or not. The interviewer subsequently put a plot indicating the sighting location on the map and got the sighting date information.

Photo 2. Interview survey at Male fishing port (25 Feb 2016)

(4) Survey items

The items included in Web-questionnaire survey and Interview survey were as follows:

- Location of sighting
- Date of sighting
- Shape and size

- Color
- Others (catch and sighting of large-size squid)

(5) Researchers

The researchers including the JICA expert are as follows.

Table 1. Name and Contents of duties

Name	Division	Contents of duties
Hino Yoshiki	JICA expert	Preliminary survey /Web-questionnaire survey /Interview survey
Islam Fahmeeda	MRC	Web-questionnaire survey
Ahsan Mohamed	MoFA	Interview survey
Fikree Ibrahim	MoFA	Interview survey

(6) Period and location of the survey

The survey period and location are as follows: the preliminary survey and the Web-questionnaire were implemented at the project office in Malé, the targeted area was all regions of Maldives.

Table 2. Period and location of each survey

Name of survey	Survey period	Location of survey
Preliminary survey	Oct - Nov. 2015	
Web-questionnaire survey	Nov. 2015 - Jul. 2016	
Interview survey	25. Feb. 2016	Malé fishing port, Kaafu atoll
	29. Feb. 2016	Hulhumale fishing port, Kaafu atoll
	10. Mar. 2016	Kooddoo island, Gaafu Alifu atoll

3.2 Survey about the sea current and the wind condition

To estimate the spawning ground of DBS egg mass which has a free-floating characteristic based on the sighting point, it is necessary to assess the sea current and the seasonal variation of wind direction. Regarding the wind information, the monthly variation of the wind direction and the wind speed on each site of the northern, central and southern parts of Maldives since June 2015 were disclosed by “Maldivian Meteorological Service” and these information were analyzed. On the other hand, it was difficult to assess the detail condition of sea current in Maldives due to the lack of accumulation of information. However the basic sea current in Indian Ocean was assessed from the documents.

4. Result

4.1 Sighting point and Monthly variation of No. of sightings of DBS egg mass

41 sighting information of DBS egg mass were collected (one egg mass was sighted at Lakshadweep island in India). 8 information out of 41 were identified to be a DBS egg mass by photos or movies. 22 information were collected by Interview survey. Among the information from fishers, there were some information based on vague memories about color and size of the object. In that case, the investigator asked the fishers about the shape and condition of egg mass and counted it as a sighting information only if the targeted object was most probably thought to be DBS egg mass, unless it is like a jellyfish. Based on the above findings, it was revealed that the DBS resources exist in the coastal area of Maldives. The detailed sightings information is presented in Table 3. The information of the length and the color of egg mass on the list is described exactly as per fishers' report.

The main sighting points concentrate in the northern and central part of Maldives, particularly, Kaafu atoll, Alifu Alifu atoll, Alifu Dhaalu atoll and Thaa atoll. More specifically about geographic features of the sighting points, the egg mass was frequently sighted on the eastern side of atolls and inside it (in the lagoon); on the other hand, it was almost never sighted on the west side of atolls. The sighting points of DBS egg mass are indicated in Figure 1.

Table 3. List of sightings of DBS egg mass

	Name of survey	Information provider	Date	Location	Length	Color	Remark
1	Preliminary survey	Travel agent	7. Jan. 2014	Maagiri Thila (Kaafu atoll)	—	—	Photo
2	Preliminary survey	Travel agent	Jan-Mar. 2014	Bandos (Kaafu atoll)	—	—	Photo
3	Preliminary survey	Travel agent	24. Feb. 2015	Dhiyamigili island (Thaa atoll)	—	—	—
4	Preliminary survey	Travel agent	2-7. Dec. 2012	Guraidhoo island (Kaafu atoll)	—	—	—
5	Interview survey	MRC staff	—	Near Landaa Giraavaru island (Baa atoll)	—	—	—
6	Preliminary survey	Travel agent	—	Near Halaveli Holiday Village (Alifu Alifu atoll)	—	—	Photo
7	Web-questionnaire survey	Travel agent	1. Mar. 2015	Huvafen Fushi, aka Nakatcha(Kaafu atoll)	(5feet?)	Translucent with pink	—
8	Web-questionnaire survey	Marine biologist	21. Nov. 2015	Dhonfan Reef (Baa atoll)	60cm	Pink	—
9	Web-questionnaire survey	Marine biologist	—	Baros (Kaafu atoll)	—	—	
10	Web-questionnaire survey	Marine biologist	20. Dec. 2014	Kanuhura(Lhaviyani atoll)	20cm	Purple/ transparent	Photo
11	Web-questionnaire survey	Marine biologist	4. Jan. 2015	Kanuhura(Lhaviyani atoll)	—	—	Photo
12	Web-questionnaire survey	—	28. Jan. 2015	Out side Dhigurah(Alifu Dhaalu atoll)	100-150cm	Light purple	Movie
13	Web-questionnaire survey	—	—	Conrad Maldives rangali(Alifu Dhaalu atoll)	3-4feet	Dark pink	—
14	Web-questionnaire survey	—	15. Jan. 2012	Bitra island(Lakshadweep, India)	150cm	Red	Photo
15	Web-questionnaire survey	Marine biologist	31. Jan. 2016	Near Dhangethi(Alifu Dhaalu atoll)	200cm	Pink	Photo
16	Web-questionnaire survey	—	30. Nov. 2015	Villimale west beach area(Kaafu atoll)	120cm	Purplish dots in a clear jelly like substance	—
17	Web-questionnaire survey	—	25. Oct. 2015	Kuramathi island(Alifu Alifu atoll)	50-80cm	Clear	—
18	Web-questionnaire survey	—	9. Nov. 2014	Kuramathi island(Alifu Alifu atoll)	50-80cm	clear	—

19	Web-questionnaire survey	—	15. Dec. 2013	(Seenu atoll)	180cm	Blue transparent	—
20	Interview survey	Reef fisherman	Jan. 2016	Gulhyfalhu(Kaafu atoll)	1feet	Dark black/ purple	—
21	Interview survey	Reef fisherman	Dec. 2015	Dhigurah & Madduvari(Meemu atoll)	1feet	Red	He saw 2 or 3 times at same area
22	Interview survey	YFT fisherman	Nov. 2015	Magoodhoo island(Faafu atoll)	60cm	Blue	—
23	Interview survey	Reef fisherman	Jan-Feb. 2013	(Meemu atoll)	6feet	Red	—
24	Interview survey	YFT fisherman	2014	30-40 mile from Lhaviyani atoll	1m	Red	—
25	Interview survey	SKJ fisherman	18. Feb. 2016	Near Huraa island(Kaafu atoll)	1m	purple/pink	*1
26	Interview survey	YFT/SKJ fisherman	—	West side of Kaafu atoll	—	—	He saw it frequently
27	Interview survey	Reef fisherman	Jan. 2016	Near Madoogali resort(Alifu Alifu atoll)	—	Red	—
28	Interview survey	SKJ fisherman	20. Feb. 2016	13 mile from Dhiffushi island(Kaafu atoll)	3feet	red/light red	—
29	Interview survey	SKJ fisherman	Nov-Feb	Thaa atoll and Laamu atoll	2～3feet	White	*2
30	Interview survey	SKJ fisherman	Feb. 2015	Hulhumale island(Kaafu atoll)	5feet	White	—
31	Interview survey	YFT fisherman	Feb. 2015	1 mile outside from Dhuvaafaru island (Raa atoll)	8feet	Red	He saw 2 or 3 egg mass
32	Interview survey	YFT fisherman	Nov. 2015	Meedhoo island(Dhaalu atoll)	10feet	Blue/red	*3
33	Interview survey	YFT fisherman	Feb. 2015	Near Thulhaadhoo island(Baa atoll)	5feet	red/white	*4
34	Interview survey	YFT fisherman	Dec. 2014	Anboodhoofindh(Kaafu atoll)	5feet	Red	—
35	Interview survey	YFT fisherman	Dec. 2015	Vaadhod island(Raa atoll)	12feet	Red	—
36	Interview survey	YFT fisherman	Feb. 2016	Near Kalhufahalafushi(Thaa atoll)	3feet	pink/red with dots	—
37	Interview survey	YFT fisherman	2015	Neyyey giri(Thaa atoll)	3feet	White	2 or 3 egg mass
38	Interview survey	YFT fisherman	—	(Thaa atoll)	—	—	Many times he saw
39	Interview survey	YFT fisherman	Feb. 2016	Theluveligaa island(Alifu Dhaalu atoll)	3feet	Red	—

40	Interview survey	YFT fisherman	Dec. 2015	Dhidhdhoo island(Haa Alifu atoll)	7feet	Red	5 or 6 at once
41	Interview survey	Diving boat	Dec. 2004	Rangali resort(Alifu Dhaalu atoll)	—	blue	—

※1 : fishers said he saw the egg mass some times in Gaafu Dhaalu atoll and Kaafu atoll but it might be jelly fish.

※2 : fishers said he saw the egg mass some times in Raamu atoll on Nov – Feb.

※3 : fishers said he saw 12 egg mass at one time.

※4 : fishers said he saw more than 10 egg mass at one time.

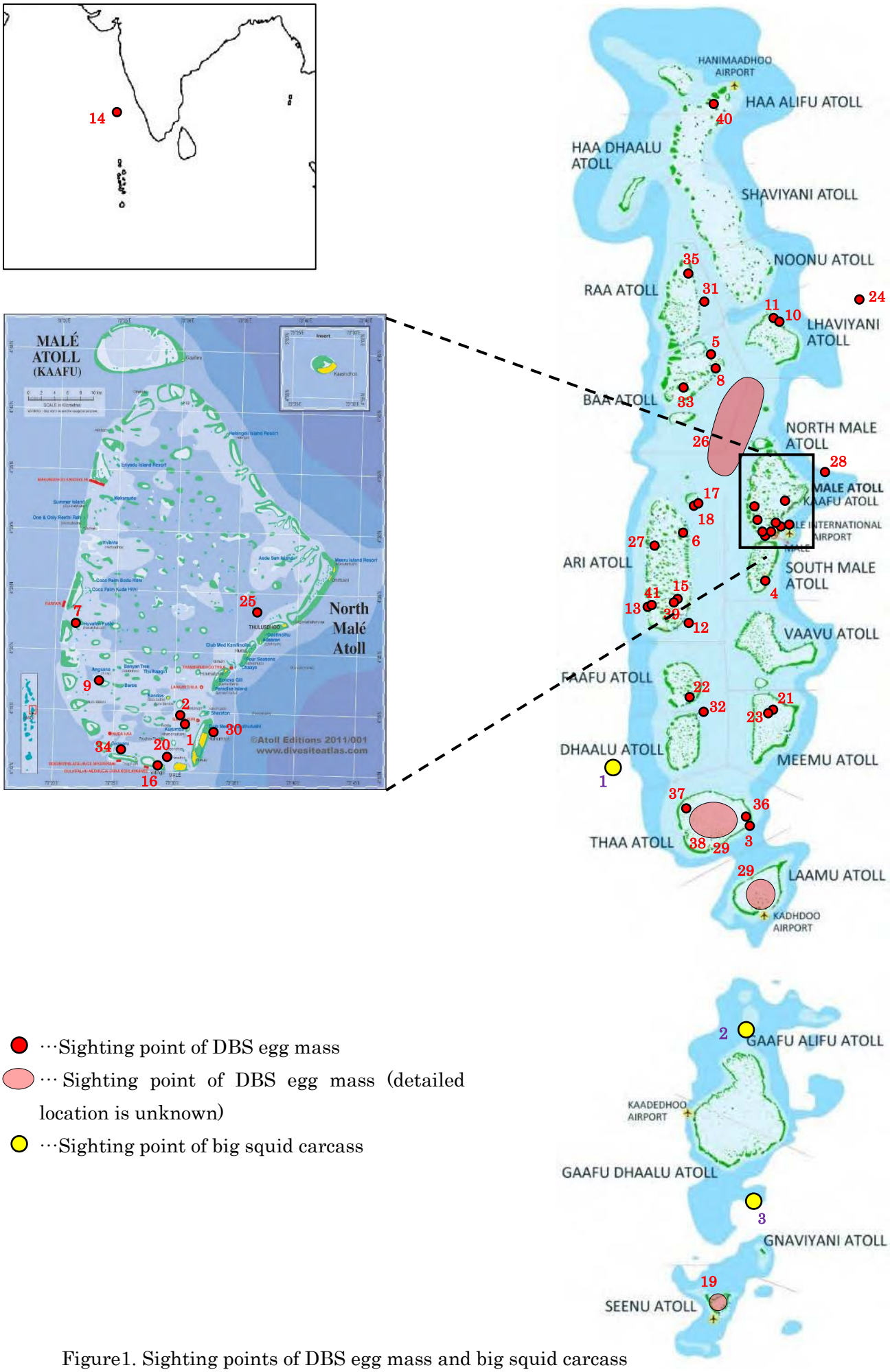


Figure1. Sighting points of DBS egg mass and big squid carcass

Out of 41 information, 30 information specified the sighting period and the monthly variation of sightings are summarized in Table 4. Note that some fishers saw the egg mass many times or saw some egg mass once but these information were counted as '1' because the detailed information was unknown.

According to Table 4, almost all the sightings occurred in between November and February. For another 3 information whose correct sighting month was unknown, the sightings occurred in 'Nov – Feb', 'Jan - Feb' and 'Jan - Mar'. Including these 3 information, more than 90% (31 of 33 information) was sighted in between November and February.

Table 4. Monthly variation of No. of sightings of DBS egg mass

Season	Northeast monsoon				Southwest monsoon						Northeast monsoon	
Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
No. of sightings	7	8	1	0	0	0	0	0	0	1	5	8

4.2 Sighting information of big squid carcass

In the interview survey for fishers, the information about sighting of big squid carcass was collected. It is difficult to ask fishers who are specialized in Skipjack and Yellowfin tuna to identify the species of squid. However since the number of species of big squid are limited, moreover, the size of these squids exceed the oval squid or cuttlefish which are caught in the coastal area of Maldives, this information might be a key to indicate the probable presence of DBS resource. The information on the length of big squid carcass from fishers might be overestimated. 5 information of big squid carcass were collected and the sighting points are indicated in Figure 1.

Table 5. Sighting information of big squid carcass

	Date of sighting	Location of sighting	Length
1	Unknown (Dec. – Apr.)	20 miles off Kudahuvadhoo island, Daalu atoll (near the FAD)	6.6 feet
2	Unknown	North of Gaafu Alifu atoll	4 feet
3	Sep. 2015	Between Gaafu Dhaalu and Gaviyani atoll	6 feet
4	Unknown	Unknown	4 feet
5	Unknown	Unknown	3 feet (half body)

4.3 Seasonal wind in Maldives

In general, 2 seasons are identified in Maldives, 1) the northeast monsoon season, from November to April and 2) the southwest monsoon season, from May to October. The main wind direction from October 2015 to September 2016 on 3 sites in Maldives (northern part:

Hanimaadhoo in Haa Alifu atoll, central part: Hulhumale in Kaafu atoll, southern part: Gan in Seenu atoll) is summarized on the table 6 (wind which blows from west is drawn in green and the one which blows from east is drawn in blue).

Accordingly, the wind switches from a westward direction to an eastward direction in the northern part and central part of Maldives in November – December, and it also switches from an eastward direction to a westward direction in March – April. On the other hand, in Gan (southern part of Maldives), the period when the wind of an eastward direction blows is shorter than that in the northern and central part. The wind blowing from a westward direction continues in November and December.

Table 6. Monthly variation of the wind direction in the 3 sites

(thin arrows: 10% - 15% of wind frequency, thick arrows : more than 15% of wind frequency)

	Northeast monsoon				Southwest monsoon						Northeast monsoon	
Mo	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Northern												
Central												
Southern												

4.4 Surface sea current of Maldivian sea

The surface sea current is an important element for the Egg Trace Method, as well as the wind direction. It is thought that the North Equatorial Current runs to west around the northern and central part of Maldives, and it runs into the same direction with the seasonal wind during the northeast monsoon season. On the other hand, the North Equatorial Current which runs to west may be disappeared by the strong seasonal wind during the southwest monsoon season (May to October), and it is thought that the Monsoon Current which runs from south-west to north-east may be occurring.

Meanwhile, in the southern part of Maldives, the current is affected by the Equatorial Countercurrent running to east, which is in an opposite direction to the North Equatorial Current, namely, it is assumed that there is a difference about current direction between northern/ central part and southern part. The presumed seasonal surface sea current is described in Figures 2 and 3.

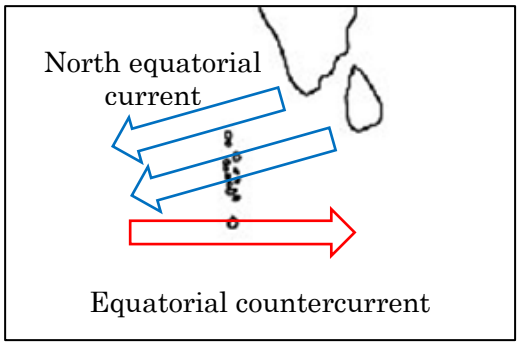


Figure 2. Surface current from Nov. to Apr.

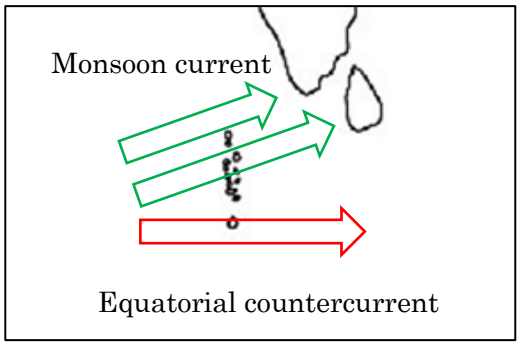


Figure3. Surface current from May. to Oct.

5. Discussion

According to the above results, it was discovered that DBS resource exists in the coastal zone of Maldives. Moreover, the spawning sea area and spawning period were investigated based on the information collected by a series of surveys. The way of investigation was that the sea area and seasons of Maldives were divided by each feature and analyzed through a matrix whose vertical and horizontal axis correspond to the sea areas and the seasons, respectively. At the end of this chapter, the proposed period and sea area of the DBS resource survey are presented.

5.1 Spawning ground and spawning season of DBS

To analyze the spawning ground and spawning season, the sea area is divided into 2 parts based on the feature described as follows. One is the northern/ central area where the surface sea current is affected by the monsoon, and the other is the southern area where the sea current runs to east throughout the year. Furthermore, each area was divided into east and west. In addition, the season was divided into 2 periods: one from November to April, when the wind from northeast monsoon prevails, and the other from May to October, when the southwest monsoon prevails.

Table 7. The possibility of spawning in each sea area and season

			Season	
			November - April (northeast monsoon)	May - October (southwest monsoon)
Sea areas	Northern and central area	Eastern coast	The sighting information in northern and central part of Maldives was concentrated in northeast monsoon season which is in between November and February, therefore there is no doubt that DBS spawns in this season in eastern coast of northern and central part of Maldives.	There is high probability that the Monsoon Current which runs east occurs on the southwest monsoon season. Therefore, assuming that DBS spawns in eastern coast of northern and central part of Maldives in May – Oct, the spawned egg mass does not reach near the atolls. Consequently, the possibility that DBS spawns in this season in eastern coast of northern and central part of Maldives cannot be denied.
		Western coast	There is high probability that the Monsoon Current which runs west occurs in the northeast monsoon season. Therefore, assuming that DBS spawns in western coast of north and central part of Maldives in Nov – Apr, the spawned egg mass does not reach near the atolls. Consequently, the possibility that DBS spawns in this season in western coast of northern and central part of Maldives cannot be denied.	There is high probability that the Monsoon Current which runs east occurs in the southwest monsoon season. Therefore, assuming that DBS spawns in western coast of northern and central part of Maldives in May – Oct, there is a high possibility that the egg mass is sighted. Otherwise, there was few sighted information in the northern and central part of Maldives in this season. Consequently, the possibility that DBS spawns in western coast of northern and central part in May – Oct is low.
	Southern area	Eastern coast	It is thought that the current flows constantly from west to east in Southern area affected by Equatorial Counter Current, and there is a possibility that the egg mass spawned in eastern coast does not reach near the atolls. Consequently, the possibility that DBS spawns in this season in eastern coast of southern part of Maldives cannot be denied.	There is no information that the egg mass was sighted from May to October in southern area. Although it cannot be concluded that DBS does not inhabit in the south area in this season and area, the possibility of the spawning is thought to be lower than in other sea areas and another season.
		Western coast	It is difficult to conclude because there are few sighted information in south area but one egg mass was sighted in Seenu atoll in November, therefore there is no doubt that DBS spawns in southern area. Moreover, taking into consideration the effect of the wind which blows from west in Nov. and the Equatorial Counter Current, there is high possibility that DBS spawns in western coast of southern part from Nov. to Apr.	There is no information that the egg mass was sighted from May to October in southern area. Although it cannot be concluded that DBS does not inhabit in south area in this season and area, the possibility of the spawning is thought to be lower than in other sea areas and another season.

Most of the sighting points were on the eastern side of atolls or inside atolls (in the lagoon) and most of the sighted period was in the northeast monsoon season in particular, from November to February. Therefore, there is a high probability that DBS spawns the egg mass from November to February on the eastern side of atolls in northern and central Maldives. However, the following points should be noted: the egg mass which is spawned in this season in the western coastal side will drift far away from the coast, so the possibility of sighting will be reduced. Besides, in the southern area, there is an information about sighting of egg mass so that there is a high possibility that the spawning area is in the western coastal side because the surface sea current runs to east in spite of the direction of the monsoon. Moreover, there is almost no information of sighting egg mass during the southwest monsoon season (May to October).

In addition, the accumulation of information about DBS ecology is insufficient; it is however estimated that the DBS spawns the egg mass where the depth of seabed is about 1,000m. The possibility that DBS spawns between western and eastern atolls is low, since most of this sea area is less than 500m in deep.

It can be concluded from the above that the DBS spawning sea area corresponds to "eastern coastal side of northern and central part" and "west coastal side of southern part" but the possibility of spawning in other areas cannot be denied. Moreover, it is estimated that the spawning period may most probably be from November to February.

5.2 Period and sea area of DBS resource survey

The most suitable implementation period for the DBS resource survey is the mating/ spawning period of DBS and the sea area is where DBS gathers for mating/ spawning. According to the interview by the experts, the fishing ground is made where the DBS gathers for mating/ spawning. In the case of pelagic squid, there is a possibility that the females move to different location from where they received the spermatophore from males, and then spawn the egg mass. At the same time, it is known that DBS has the similar behavior when it chooses the spawning sea area, i.e. the fast flowing sea area. Consequently, it is most efficient to implement the initial resource survey at the estimated spawning period and in the estimated spawning sea area. In fact, in the case of a JICA technical cooperation project in Vanuatu, the mature DBS was caught near the sighting location of egg mass during the estimated spawning season. Based on these factors it is suggested that the period of DBS resource survey be from November to February, and the sea area is suggested as below.

Table 8. Proposed trial operation areas of DBS resource survey
◎: strongly proposed ○: moderately proposed
△: not strongly proposed but there is a possibility

	Western coastal side	Eastern coastal side
Northern	△	◎
Central	△	◎
Southern	○	△

＜Reference＞

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Attachment 2

Equipment list procured in Japan

			Q'ty	unit	price	total
A. Diamond back squid fishing materials						
1	Fishing line (Leader line)	Super top No.50 x 100 m coil	75	coils	¥1,900	¥142,500
2	Snap for branch line	2.6 x 100 x 2Φ with swivel BL	50	pc	¥150	¥7,500
3	Snap for branch line	Mini snap 2.0 x 80 x 2Φ with swivel	100	pc	¥240	¥24,000
4	Swivel	OYAKO 3 x 4	50	pc	¥80	¥4,000
5	Rubber cushion	5 mm Φ x 100 meter	1	coil	¥30,000	¥30,000
6	Nylon monofilament fishing line	No.40 x 500 m coil	1	coil	¥4,350	¥4,350
7	Underwater light	GII type LED Blue light	20	pc	¥1,070	¥21,400
8	Spare bulb for above	LED Blue light	10	pc	¥380	¥3,800
9	Lead	Oval shape 30 g 2 kgs pack	10	bag	¥1,510	¥15,100
10	Diamond back squid jig	1 x 2 23 cm All white	20	pc	¥1,210	¥24,200
11	Plastic trunk for Diamondback squid jig	Plastic body Fluorescent	10	pc	¥270	¥2,700
12	Plastic trunk for Diamondback squid jig	Plastic body White	10	pc	¥270	¥2,700
13	Metal skewer for Diamondback squid jig	Stainless steel 1x2, 23 cm	20	pc	¥700	¥14,000
14	Swivel	with 75 grm lead	30	pc	¥310	¥9,300
15	O ring	for connecting Diamondback jig and mini snap	100	pc	¥30	¥3,000
					S. Total	¥308,550
B. Drift vertical line fishing materials						
1	Rubber cushion	5 mm Φ x 1 m	20	pc	¥1,500	¥30,000
2	Swivel	No.4 x 5	200	pc	¥60	¥12,000
3	Nylon monofilament fishing line	No.40 100 meter coil	1	coil	¥1,400	¥1,400
4	Nylon monofilament fishing line	No.24 100 meter coil	5	coil	¥1,000	¥5,000
5	Nylon monofilament fishing line	No.22 100 meter coil	5	coil	¥1,000	¥5,000
6	Fishing hook	Mutsu N. 24 (200 pcs/pack)	2	pack	¥4,400	¥8,800
7	Snap with swivel	Swivel No.5/0	50	pc	¥130	¥6,500
8	Plastic frame	Round shape, PVC made 265 mm in diameter	15	pc	¥2,800	¥42,000
					S. Total	¥110,700
C. Common materials						
1	Mark buoy flag	Vinyl flag approx. 40 cm x 30 cm	15	pc	¥2,710	¥40,650
2	Mark buoy pole	FRP pole 3 cm Φ x 200 cm	15	pc	¥8,240	¥123,600
3	Mark buoy float	EVA float Buoyancy 4kgs	18	pc	¥1,760	¥31,680
4	Fishing float	Spongex fishing bullet buoy 7" x 14 "	30	pc	¥3,800	¥114,000
5	GPS	Etrex with Maldives sea chart	2	pc	¥46,000	¥92,000
6	Scissors	330H-Y	2	pc	¥1,800	¥3,600
7	Electric line hauler	MLD-G1, DC24V/250W, Max 80 Kg/30 RPM	1	set	¥468,000	¥468,000
8	Spare reel	Stainless steel made 380 mm in diameter	2	pc	¥55,000	¥110,000
9	Spare guide for line hauling	Stainless steel made	2	pc	¥19,100	¥38,200
10	Plastic fish basket	Santainer Plastic A#85 (71 x 47 x 33 cm) Blue	10	pc	¥5,000	¥50,000
11	Rope	Polypropylene fishing rope 5 mm Φ x 200meter	10	coil	¥1,224	¥12,240
					S. Total	¥1,083,970
					Total	¥1,503,220
		Air shipment charge (Export packing, Export Customs Clearance, Air Freight)				¥637,550
		Cargo insurance				¥8,564
		CIF MALE/MALDIVES				¥2,149,334

Attachment 3

Summary of Deep-sea fishery resources survey results (demersal fishes)

Resource survey data							demersal fish data		
Fishing operation #	Date	Fishing area (Atoll)	Current direction & strength	Wind direction & strength	Estimated depth	Time of capture	Species	Fork length (cm)	Weight (kg)
1	2017/2/12	2NM E of Dhiffushi (North Male)	to W moderate	from NE moderate	—	—	—	—	—
2	2017/2/14	SE of Guraidhoo (South Male)	to W moderate	from NE moderate	—	—	—	—	—
3	2017/2/15	NW of Rasdhoo (Alifu Alifu)	to W moderate	from NE moderate	—	—	—	—	—
4	2017/2/21	West reef edge of Maamakunudhoo (Haa Dhaalu)	to S moderate	from N moderate	300m	17:19	*Macolor macularis* or *M. niger*	52	2.0
					300m	17:39	Serranidae (not specified)	105	14.4
					300m	17:39	*Wattsi mossambico*	41	1.5
					300m	17:39	*Aphareus rutilans*	52	1.9
					300m	17:39	*Pristipomoides filamentos*	49	1.5
5	2017/2/22	E of Dhuvaafaru reef (Raa)	to N strong	from N moderate	200m	15:58	*Lethrinus microdon*	38	1.5
6	2017/2/26	E of Veyvah (Meemu)	to W strong	from N weak	300m	17:34	*Pristipomoides auricilla*	32	0.6
					200m	17:40	*Lethrinus conchyliatus*	48	1.6
					200m	17:40	*Epinephelus chlorostigma*	42	1.0
7	2017/2/28	3NM SW of Hulhudheli (Dhaalu)	to SW strong	from E weak	300m	—	*Aphareus rutilans*	80	6.0
					150m	—	*Aphareus rutilans*	66	4.0
					300m	—	*Etelis carbunculus* or *E. coruscans*	64	3.5
					300m	—	*Pristopomoides* sp.	51	2.0
					300m	—	*Epinephelus chlorostigma*	44	1.2
8	2017/3/1	S of Fenfushi (Alifu Dhaalu)	to SW moderate	from NE strong	300m	—	*Pinjalo lewisi*	42	1.5
					300m	—	*Epinephelus miliaris*	45	1.0
					300m	—	*Pristipomoides auricilla*	33	0.6
					300m	—	*Pristipomoides auricilla*	29	0.5
					300m	—	*Epinephelus areolatus*	37	0.7

Attachment 4

Summary of DBS resource survey results

resource survey data					DBS data					Catch point and time		
Fishing operation #	Date	Fishing area (Atoll)	Current direction & strength	Wind direction & strength	ID # of DBS	Weight (kg)	Mantle length (cm)	Gonard weight (g)	Sex	GPS Coordinates of capture		Time of capture
										N	E	
1	2016/11/14	9.5NM E of Himmafushi (North Male)	to SW weak	from W weak	1	9.42	68	30	M	04 18.417	73 42.750	7:43
					2	6.18	58	24	M	04 17.867	73 42.367	12:05
					3	1.77	38	4	M			
2	2016/11/14	11NM E of Dhiffushi (North Male)	to N weak	from W weak	—	—	—	—	—	—	—	—
3	2016/11/15	9NM NNE of Dhiffushi (North Male)	to N weak	from N weak	4	6.18	59	26	M	04 35.433	73 43.530	6:55
					5	3.65	48	16	M	04 37.333	73 43.550	9:53
4	2016/11/16	12NM NE of Keyodhoo (Vaavu)	to SW weak	from W weak	—	—	—	—	—	—	—	—
5	2016/11/16	8NM E of Graidhoo (South Male)	to NE weak	from W weak	6	3.57	49	14	M	03 53.441	73 35.891	15:37
					7	5.87	55	24	M	03 53.568	73 36.073	15:49
					8	3.99	49	16	M			
6	2016/11/17	9.5NM E of Himmafushi (North Male)	to N weak	from W weak	9	4.08	50	22	M	04 18.727	73 42.795	9:00
					10	5.21	52	60	F			
7	2016/11/20	5NM NE of Madhiriguraidhoo (Lhaviyani)	to SW moderate	from NE moderate	11	1.70	35	6	M	05 33.238	73 36.647	8:45
					12	3.30	47	16	M			
					13	3.89	49	16	M	05 33.287	73 36.838	9:00
					14	1.60	37	6	M	05 32.838	73 36.323	9:20
					15	9.49	61	34	M	05 32.975	73 36.464	9:35
					16	3.89	51	20	M	05 32.657	73 36.097	10:25
8	2016/11/21	7NM NNE of Feevah (Shaviyani)	to N weak	from NW weak	—	—	—	—	—	—	—	—
9	2016/11/21	7NM NE of Kedhikulhudhoo (Noonu)	to NW weak	from NW weak	17	7.37	63	34	M	06 02.313	73 29.406	15:15
10	2016/11/22	7NM E of N. Manadhoo (Noonu)	to SSW moderate	from W weak	18	11.34	70	46	M	05 43.913	73 32.203	8:46
					19	11.65	71	480	F			
11	2016/11/23	7NM E of N. Manadhoo (Noonu)	to SSW weak	from W moderate	20	4.55	53	20	M	05 44.272	73 32.842	10:45
12	2017/2/12	10NM NE of Male (North Male)	to E weak	from NE moderate	21	7.6	65	35	M	04.17 068	73.42 974	8:00
					22	7.4	60	190	F	04.17 580	73.42 703	8:30
					23	4.9	51	15	M			
					24	10.2	68	30	M	04.18 157	73.42 728	8:50
13	2017/2/13	8NM N of Dhiffushi (North Male)	to W weak	from NE strong	25	4.0	46	20	M	04.34 293	73.43 574	6:37
					26	4.2	46	10	M	04.32 674	73.43 929	10:20

14	2017/2/14	6NM E of Mafushi (South Male)	to W moderate	from NE moderate	27	10.0	64	350	F	03.53 653	73.34 847	10:26
15	2017/2/15	23NM W of Thoddoo (Alifu Alifu)	to E strong	from NE weak	—	—	—	—	—	—	—	—
16	2017/2/15	19NM W of Thoddoo (Alifu Alifu)	to W very strong	from E moderate/strong	—	—	—	—	—	—	—	—
17	2017/2/19	5NM NE of Madhiriguraidhoo (Lhaviyani)	to SW moderate	from N moderate	28	6.8	60	50	M	05.33 879	73.35 094	8:54
					29	10.2	64	340	F			
					30	11.8	68	50	M	05.34 847	73.32 447	13:47
					31	6.0	56.3	40	M	05.35 058	73.31 587	14:10
18	2017/2/20	7NM SE of Manadhoo (Noonu)	to N strong	from N weak	32	9.8	63	260	F	05.44 116	73.31 720	7:28
					33	4.6	46	75	F	05.43 236	73.30 061	10:26
19	2017/2/21	11NM W of Hulhudhuffaaru (Raa)	to S moderate	from E weak	34	7.0	58	120	F	05.52 286	72.49 156	7:15
					35	6.6	58	40	M			
					36	14.0	76	580	F	05.52 454	72.49 418	7:50
					37	9.0	67	50	M	05.52 262	72.49 714	7:58
					38	9.6	66	260	F			
					39	9.5	67	50	M	05.52 319	72.49 181	9:04
					40	11.1	70	420	F			
					41	15.0	77	510	F	05.53 244	72.50 679	9:15
					42	11.2	71	370	F	05.52 583	72.49 611	9:34
					43	12.8	75	60	M	05.53 328	72.50 771	10:03
					44	9.0	66	50	M	05.52 516	72.49 679	10:31
					45	12.0	70	380	F			
					46	11.8	70	440	F	05.53 208	72.50 586	11:00
					47	15.4	81	65	M			
					48	16.8	82	60	M	05.53 331	72.50 871	11:19
					49	12.0	73	50	M	05.53 443	72.51 040	11:31
					50	9.2	67	45	M	05.53 338	72.51 219	11:55
20	2017/2/22	8NM S of Maamakunudhoo (Shaviyani)	to W strong	from N weak	51	13.8	76	450	F	06.02 930	72.33 465	9:41

21	2017/2/26	12NM NE of Guraidhoo (Thaa)	to W strong	from N weak	52	16.0	81	70	M	02.28 584	73.27 609	6:35
					53	7.5	62	40	M	02.27 195	73.25 458	11:52
22	2017/2/27	12.5NM SE of Muli (Meemu)	to SW moderate	from NE weak	54	12.0	72	40	M	02.45 065	73.41 782	7:45
					55	11.0	70	135	F			
					56	5.5	56	20	M	02.43 250	73.39 140	11:34
23	2017/2/28	7 NM W of Hulhudheli (Dhaalu)	to N moderate	from SW moderate	—	—	—	—	—	—	—	—
24	2017/3/1	12NM W of Fenfushi (Alifu Dhaalu)	to W very strong	from NE strong	57	8.5	67	40	M	03.29 645	72.36 412	10:55
					58	13.0	71	400	F			
					59	15.0	77	50	M	03.29 873	72.36 496	11:17