SOBA 4.1: FISHERIES IN THE AYEYARWADY BASIN

AYEYARWADY STATE OF THE BASIN ASSESSMENT (SOBA)

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Disclaimer
"The Ayeyarwady State of the Basin Assessment (SOBA) study is conducted within the political boundary of Myanmar, where more than 93% of the Basin is situated."

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LIST OF ABBREVIATIONS

°C	degrees Celsius
ADB	Asian Development Bank
BOBLME	Bay of Bengal Large Marine Ecosystem project
CGD	Centre for Global Development
cm	centimetres
CPUE	catch-per-unit-effort
DoF	Department of Fisheries
FAO	Food and Agriculture Organization of the United Nations
FAO FIGIS	Food and Agriculture Organization of the United Nations – Fisheries Global Information System
FAO-NACA	Food and Agriculture Organization and Network of Aquaculture Centres in Asia-Pacific
ha	hectare
ICEM	International Centre for Environmental Management
IFReDI	Inland Fisheries Research and Development Institute
JICA	Japan International Cooperation Agency
kg	kilogram
LIFT	Livelihoods and Food Security
m	metres
MFP	Myanmar Fisheries Partnership
MMK	Myanmar Kyat
MMRD	Myanmar Marketing Research and Development
MNPED	Ministry of National Planning and Economic Development
MYFish	Improving Research and Development of Myanmar's Inland and Coastal Fisheries project
NWRC	National Water Resources Committee
SEAFDEC	Southeast Asian Fisheries Development Center
SOBA	State of the Basin Assessment
SOBA 4	State of the Basin Assessment 4: Fisheries and Biodiversity in the Ayeyarwady Basin
UNDP	United Nations Development Programme
UNICEF	United Nations Children's Emergency Fund
USD	United States dollar
WBG	World Bank Group

EXECUTIVE SUMMARY

Myanmar fish production based on updated fisheries statistics comprises approximately one-third each of inland capture fish, marine capture fish and aquaculture fish, collectively totaling 2.9 million tonnes in 2015.

After a peak in 2005, there has been a decline in marine fish production, and the trend in inland fish production has plateaued – in contrast, aquaculture shows a steady increase over this period, of which 99% of production is from inland waters.

The economic value of freshwater aquaculture production was estimated at USD 1.6 billion in 2014, but declined to USD 1.3 billion in 2015.

Fisheries provide full-time and part-time jobs for about 3.2 million people, with around 12–15 million people in Myanmar generating income through fisheries.

Second only to rice, fish is a major contributor to Myanmar's national diet, accounting for approximately 60% of animal protein intake and supplying amino acids, oils and essential micronutrients such as calcium, iodine and some vitamins.

The Ayeyarwady River Basin (ARB) features at least 388 fish species; 311 of these species are present in the Myanmar portion of the watershed, of which half (193) are endemic and 26% (100) are known only from Myanmar.

Hinthada Township has the highest ecological value from a fisheries protection perspective, followed by Ingapu, Myanaung, Yandoon, and Twantay.

Main challenges in the sector consist in lack of institutional capacity, lack of data to inform management, lack of monitoring and enforcement and risks inherent to dam development.

Main opportunities in the sector consist in better interagency coordination, development of fisheries co-management, and development of reservoir fisheries.

Overall, the study results in eight major findings for which the confidence level is high:

- Myanmar capture fisheries are very high production by global standards.
- Fisheries provide an essential contribution to rural food and nutrition security.
- Fisheries also contribute significantly to rural livelihoods, in particular in the delta.
- The contribution of *inland* capture fisheries to total fish production (one-third) is economically and socially important.
- There are clear signs of fisheries production decline in the delta.
- Fish resources are threatened by destructive practices (electrofishing, poisoning, habitat destruction).
- People call for a better enforcement of the existing legislation.
- There is a need to set up a fisheries monitoring system based on field sampling.

This leads to eight main recommendations:

- Take action against electrofishing and poisoning (urgent need).
- Increase the capacity of DoF in fisheries statistics at all levels and move towards a computer-based system (urgent need).
- De-link data collection and statistics from the "target planning process" (urgent need).
- Put in place a standardized and sample-based data collection system for fisheries and aquaculture, and implement a pilot monitoring project in at least one or two divisions.
- Initiate an assessment of the impact of hydropower development on fisheries resources and food security.
- Progressively allow the conversion of agricultural land into fish ponds.
- Improve law enforcement, including through i) increased cooperation between the authorities and the resource users, and ii) between different government departments.
- Progressively develop inland fisheries co-management initiatives.

1 FISHERIES SYSTEMS

1.1 Ayeyarwady Fishing Systems

There are five categories of fisheries in the 1991 *Freshwater Fisheries Law*: 1) leasable fisheries, 2) tender licence fisheries, 3) non-licence fisheries, 4) implement licence fisheries, and 5) reserved fisheries. Reserved fisheries correspond to places where or periods during which fishing is prohibited. Implement licence fisheries correspond to fisheries in which the implements (usually called "gear") are licenced. Non-licence fisheries correspond to open access fisheries (i.e., the free access to certain zones, using certain implements). Tender licence fisheries and the implement licence fisheries are also sometimes named "tender licence open fisheries" and "implement licence open fisheries," respectively, referring to open waters (rivers and streams) and not to open access fisheries.

In practice and in statistics, three major inland fishery categories are commonly referred to: 1) leasable fisheries, 2) tender lot fisheries, and 3) open access fisheries.

1.1.1 Leasable fisheries

The lease system corresponds to the allocation of a fishing area in a floodplain. Leasable fisheries are locally known as "inn" fisheries.

A description of leasable fisheries is provided by the Food and Agriculture Organization and Network of Aquaculture Centres in Asia-Pacific (FAO-NACA, 2003):

> "[Leasable fisheries are] almost exclusively key fishing grounds on floodplains which are primarily fished through the erection of barrage fences around the lease area with fish collected in various collection pens or traps. The peak season involves capturing fish migrating off the floodplain at the beginning of river draw-down [August to October]."

The original number of leasable fisheries traces back to 1905 with the *Burma Fisheries Act* and the identification of leasable sites (e.g., oxbow lakes). Prior to World War II, there were 4,006 leasable fisheries, with some erosion over time mainly due to siltation and conversion to agriculture. According to Department of Fisheries (DoF) reports, the number of leasable fisheries has declined slightly from 3,481 in 20002001 to 3,304 in 2014--2015 (DoF, 2011a; DoF, 2015). The number of leaseholds reported in other reviews during the same period varies from 2,084 in 2004-2005 (Tuan Duan, 2008) to 3,722 in 2003 (FAO-NACA, 2003) and 20052006 (Food and Agriculture Organization of the United Nations [FAO], 2010). Some studies also highlight that 6 to 7% of all leaseholds are not exploitable (FAO-NACA, 2003; Oo, 2010).

Leasable fisheries are attributed for 1, 3, or sometimes 5 years by the DoF to the highest bidder through auction or directly to communities at auction floor price. At the end of a lease period, the fishery is offered for bidding at a floor price equal to the average price of the last 5 years. An on-going study of leasable fisheries by WorldFish and the DOF reveals that despite a slight price reduction every 5 years due to averaging of the annual price over that period of time, the overall trend is a constant increase of the leasable fishery floor price, with a doubling of the price over 16 years. The fact that the floor price is never reset to reflect the actual fish productivity acts as an incentive to overfish, which is detrimental to sustainability. Fine-tuned allocation mechanisms that reflect the actual status of the resource should be considered.

A recent survey of 180 leasable fisheries, representing different agro-ecological and salinity zones, conducted by WorldFish in the Ayeyarwady and Yangon Regions (Zi Za Wah et al., 2016) concluded the following:

- Ninety-six percent of the leases are associated with large rivers, river channels, or a combination of rivers and wetlands (43% of the leases also contain seasonal wetlands).
- The price of leases varies greatly, from United States dollar (USD) 50 to USD 165,000 per unit (i.e., USD 0.9 to USD 36,000 per hectare [the latter case in Bogale Township]). This value reflects the diversity in size, fish productivity, and species composition of each lot.
- A large majority of leases are affected by water withdrawal for purposes other than fisheries, such as agriculture and domestic uses.

Leasable fisheries usually provide an important source of employment to nearby villagers and, even when operated by businessmen, can support up to 100 families (FAO-NACA, 2003; Zi Za Wah et al., 2016).

In December 2014, 11 research leasable fisheries were established for the first time by DoF in four states and seven regions, with the aims of preventing the extinction of indigenous species and fisheries habitat, promoting fish production, and collecting data related to leasable fisheries (DoF, 2015).

1.1.2 *Tender lot fisheries*

Tender lot fisheries are stretches of river for which fishing rights are attributed by DoF to an operator for the use of a specific type and number of fishing gears (usually stow nets). Tender licences are issued by the district fishery officer, often to business operators who sub-lease fishing rights to fishery operators. The number of stow nets in the river stretch is usually fixed as part of the tender agreement. Tender lot owners also give access, against remuneration, to small scale fishers who can operate between stow nets. Like in the leasable fishery system, until 2012, tender lots were directly allocated by the Ministry of Livestock and Fisheries. Since 2012, they have been auctioned by DoF at the state/division level to the highest bidder (Venkatesh, 2015).

1.1.3 *Open access fisheries*

Access to open fishing grounds is free, but most fishing gears used require a licence, which is issued by the district fishery officer for a yearly set fee (FAO-NACA, 2003; Lamberts and Wah, 2008). There are 16 small fishing gear types which, for a limited number of gear units, do not require a licence.

Table 1: Fishing gear types allowed without licence in freshwater and brackish open access fisheries, and number permitted (#) for each gear type

Freshwater		Brackish Water	
Fishing gear type	#	Fishing gear type	#
Hook and line	3	Scoop net (<4.5')	1
Pole and line	10	Bush-bundle basket (<6')	1
Pole and line	3	Bag net for small shrimp	1
Long line	1; 20 hooks	Bag net	1
Hook and line	3	Drift gill net	1
Cast net (<11', without boat)	1	Stationary trap	5
Men push net (<4.5')	1		
Scoop net (<3')	1		
Prawn/fish small trap	20		
Fish trap	3		
Drop door trap	3		
Boat with jump-platform	1		
Spear	1		
Drop door trap different design	1		
Bush-bundle basket	1		
Plunge basket/Cover pot	1		

Open access fisheries are extremely important to local populations, particularly the landless for whom fishing requires little investment (as little as USD 10 for a small fishing net) and is a source of food and possibly income (United Nations Development Programme [UNDP], 2004: Tuan Duan 2008). Aung Htay Oo (2010), however, reports that there is an increasing tendency to auction, as tender sites, the fishing rights of selected parts of open water areas.

1.2 Fishing Methods

The most common fishing techniques used in inland fisheries today are drift net, gill net, traps, pots, pole-and-line, stationary traps, and bamboo stake traps in the near shore of rivers (FAO, 2011). The use of fishing gear by leaseholders varies depending on fishing ground characteristics. Gill nets, stationary bamboo traps, and stationary bamboo fish filter traps are used across various fishing grounds. Stow nets are more common in main rivers and river channels, and filter traps are more adapted for seasonal wetlands (Zi Za Wah et al., 2016).

Fishing in open water fisheries is often conducted using non-motorized, traditional wooden crafts (Aung Htay Oo, 2010). Types and subtypes of gear have been broadly classified as follows (Khin Maung Aye et al., 2006 and Figure 1):

- Gill nets, including drift gill nets, set gill nets, and trammel nets;
- Hook and line, including long line, hand line, and pole and line;
- Traps, including fish traps, bamboo stake filter traps, stow nets, and drop-door traps;
- Surrounding nets, including small, large, and net fences;
- Cast nets, including small and large;
- Lift nets, including portable lift nets, stick-held dip nets, and Chinese dip nets;
- Push nets, with or without bags;
- Others, including Inle baskets, eel clamps, plunge baskets, cover pots (with or without tamarind wood sacred line), bush bundle baskets, small bag nets, beam trawls, multipronged burbles spears, and coordination with hunting dolphins.

Figure 1 – Inland fishing gear of Myanmar: *Courtesy U Win Ko Ko, Department of Fisheries*

1.3 Stocking

Stocking of inland waters, i.e. releasing fish produced in hatcheries into water bodies, floodplains and rivers, is a practice whose magnitude is unique to Myanmar. Stocking has been in practice since 1967 (FAO-NACA, 2003), and the purpose of such stocking is to "enhance" natural fish production and recruitment (UNDP, 2004); thus, leasable fisheries managers are compelled to follow stocking practices.

The majority of seed stock production comes from government hatcheries. Fingerlings are produced for aquaculture stocking as well as for sale to leasable fisheries. Fingerling size generally range from 1.25–2.5 centimetres (cm) in length at time of sale. Table 2 lists the quantities of fish fry and fingerlings released in different types of environments over a period of 10 years.

Table 2 - Number of seed stocked (in millions) in different inland waters of Myanmar over 10 years *(Aung Htay Oo, 2010)*

	Number Stocked (Millions of Fish)					
Years	Ayeyarwady River	Dam Reservoirs: Number of Reservoirs	Dam Reservoirs: Number Stocked	Natural Rivers and Streams	Ponds	Rice-Fish Culture
2005 to 2006	199.06	218	117.79	56.18	25.49	6.17
2006 to 2007	214.92	228	85.93	44.38	6.04	6.55
2007 to 2008	181.45	219	90.62	80.4	3.18	7.08
2008 to 2009	197.10	228	103.17	91.72	3.41	7.10
2009 to 2010	182.70	228	110.17	75.98	2.46	7.44

By law, leasable fisheries operation requires spending 30% of the value of the lease on buying stock from government hatcheries and maintaining the lease environment (Khin Maung Aye et al., 2006).

Rohu carp, *Labeo rohita,* is the most common species stocked followed by silver barb *Barbonymus gonionotus,* and catfish *Catla catla* (Zi Za Wah et al., 2016). In addition, some indigenous species are stocked in natural environments (Aung Htay Oo, 2010). Approximately 79% of leaseholders in the Ayeyarwady Delta stock their area with fingerlings.

To sustain adequate genetic diversity, fishers will return a certain number of possible breeders to government hatcheries in areas where stock have been released. Furthermore, as broodstock individuals get older (around 7 years or more), they become less productive, thus replacement occurs every 1 to 5 years (Aung Htay Oo, 2010).

There is little research on the benefits and impacts of supplying natural water bodies with cultured fish.

Fishers complain about competition sometimes apparent with fish stocking (Johnstone et al., 2013). In the Duva leasable fishery in the Hinthada District of the Ayeyarwady Region, 10 years of annual stocking of fingerlings (carp species, tilapia, and tarpian species) led to a serious decrease of the wild stock. In 2007, only 7.4% of the 761 metric tons harvested were species originally existing in the area (project report Improving Research and Development of Myanmar's Inland and Coastal Fisheries [MYFish], 2013a). Some experts suggest breeding of naturally occurring fish would be a suitable measure to take (Edwards, 2009; MYFish, 2013a).

Aung Htay Oo (2010) reports that artisanal fisheries near rivers have higher catch rates, but there is uncertainty as to what basis this claim is made. This author also states that there is a lack of evidence to support the potential issues associated with capture stocking and subsequent genetic diversity loss in wild stocks. Without reference to research, this discussion requires further investigation.

In fact, stocking, even if technically ideal, cannot have the same environmental impact or productivity as there is variance between environments, such as fully open waterways (floodplain area, rivers, and creeks) and enclosed water bodies (oxbow lakes and reservoirs).

A lack of monitoring leaves a knowledge void with regards to the potential benefits of stocking, how to optimize production, and subsequent cost effectiveness. There are challenges in assessing the quantity and quality, including age, size, and health of stocked fish species. Investment in monitoring and testing is required (Venkatesh, 2015). This could aid in streamlining stocking efforts, increasing productivity, reducing costs, and minimizing harmful impacts. Activity could be substantially improved with the development of guidelines, including information on species to be stocked, optimal density and size, target water bodies, and timing (Johnstone et al., 2013).

Researchers state that social factors need to be taken into consideration as well. Prevalent social traditions and hierarchies permeate the sector, leading to fish stocking benefits disproportionately profiting an elite group (De Silva and Funge-Smith, 2005). In Myanmar, this social advantage will require careful consideration to leverage a stocking program that contributes to mitigating poverty among the poorest fishers.

2 FISHERIES STATISTICS

2.1 Tools Required for Fisheries Monitoring

Monitoring fishery resources of the Ayeyarwady Basin, particularly inland fisheries, is an essential requirement for the long-term management of the basin. Over the years, several tools have been identified by various agencies to monitor both biological and socioeconomic components of the sector. Monitoring aims to produce field-based regional and national statistics, documenting the status of the resource, including the exploitation of and benefit from.

Listed below is a summary of several monitoring tools, with a focus on tropical, inland, and small-scale fisheries.

Comprehensive reviews include the following:

- A fishery manager's guidebook (Cochrane, 2002; in particular its chapter on Fishery Monitoring);
- *Socioeconomic Monitoring Guidelines for Coastal Managers in Southeast Asia* (Bunce and Pomeroy, 2003; a key reference for socioeconomic aspects);
- *Management Guidelines for Asian Floodplain River Fisheries* (Hoggarth et al., 1999; guidelines relevant to a major environmental component of the Ayeyarwady Basin);
- *Guidelines for Designing Data Collection and Sharing Systems for Co-Managed Fisheries* (Halls et al., 2005; a key FAO reference);
- *Small-Scale Fisheries Management* (Pomeroy and Andrew, 2011; major principles required for fisheries management in a context similar to that of the Ayeyarwady Basin);
- *Guidelines for an Ecosystem Approach to Fisheries Management* (Pomeroy et al., 2013; to integrate local community and environmental sustainability to fisheries management).

More specifically, these guidelines emphasize the need to monitor the following aspects of the fisheries sector:

Resource exploitation

- Monitoring total yield;
- Monitoring fishing effort and catch-per-unit-effort (CPUE);
- Monitoring of fishing exploitation modalities (intensity, mortality, and selectivity).

Biological aspects

- Biological composition of the catch (value of dominant species);
- Biological monitoring of target species (maximum size, size at maturity, etc.);
- Monitoring habitat health.

Socioeconomic aspects

- Socioeconomic monitoring at the household level (benefits from fisheries);
- Monitoring of fisheries governance modalities and effectiveness.

While acknowledging the relevance of local knowledge, an absence of standardized monitoring tools to flag issues and provide warning constrains managers and decisions-makers by imperfect knowledge of the status of the resource. When the information generated is not fully underpinned by field-based data, they may face, in some cases, contradictory information originating from official channels and from fishers and traders.

2.2 Fisheries Monitoring: Main Data Available

2.2.1 *Statistics until 2016*

According to DoF, fisheries produced 5.59 million metric tons in 2015-2016, including 1.58 million metric tons of freshwater fish from inland capture fisheries, 1.01 million metric tons from freshwater aquaculture, and 3 million metric tons of marine fish. According to these statistics, this corresponds to roughly half of production coming from marine fisheries and one quarter from aquaculture and freshwater fisheries, respectively. The trend over the years shows a steady increase of both inland and marine capture fisheries, with an average annual growth of 11% in inland capture fisheries and a similar growth of 8% in both marine fisheries and aquaculture.

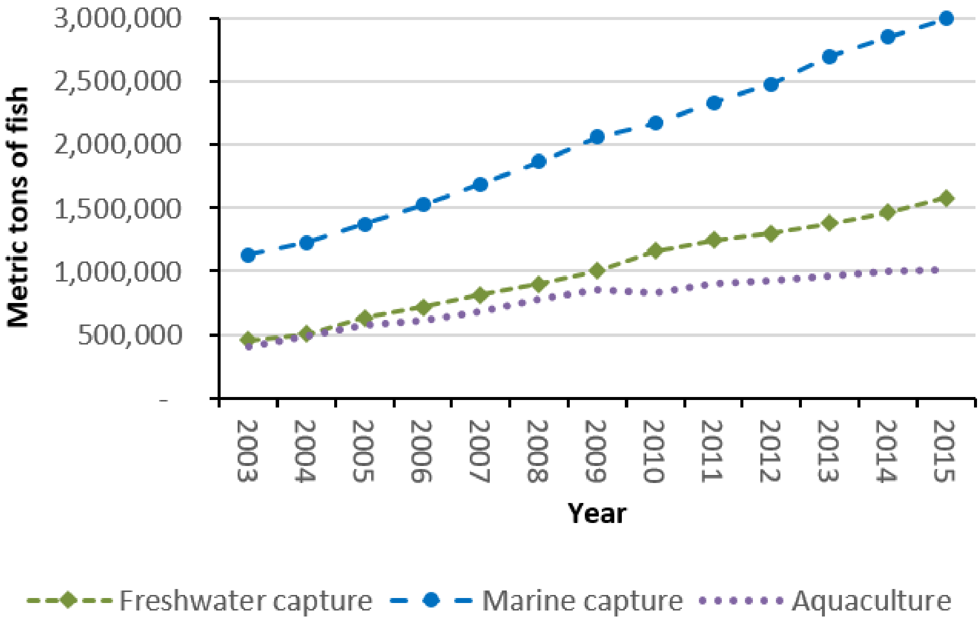


Figure 1 – Trends in marine capture fisheries: *Freshwater capture fisheries and aquaculture between 2003 and 2015 according to the Department of Fisheries (DoF, 2011, 2014, 2016).*

At the township level, the data compiled during the course of this project from DoF offices in townships along the Ayeyarwady River (2015-2016 data) indicate the spatial distribution of the yield, with a majority of catches in the delta in Bogale, Danubyu, Dedaye, Maubin, Mawlamyingyun, Nyaungdon, Pyapon, and Thayarwady. Upstream of the delta, only three townships feature a similar, although slightly lower, catch: Kungyangon, Monyo, and Kyunhla.

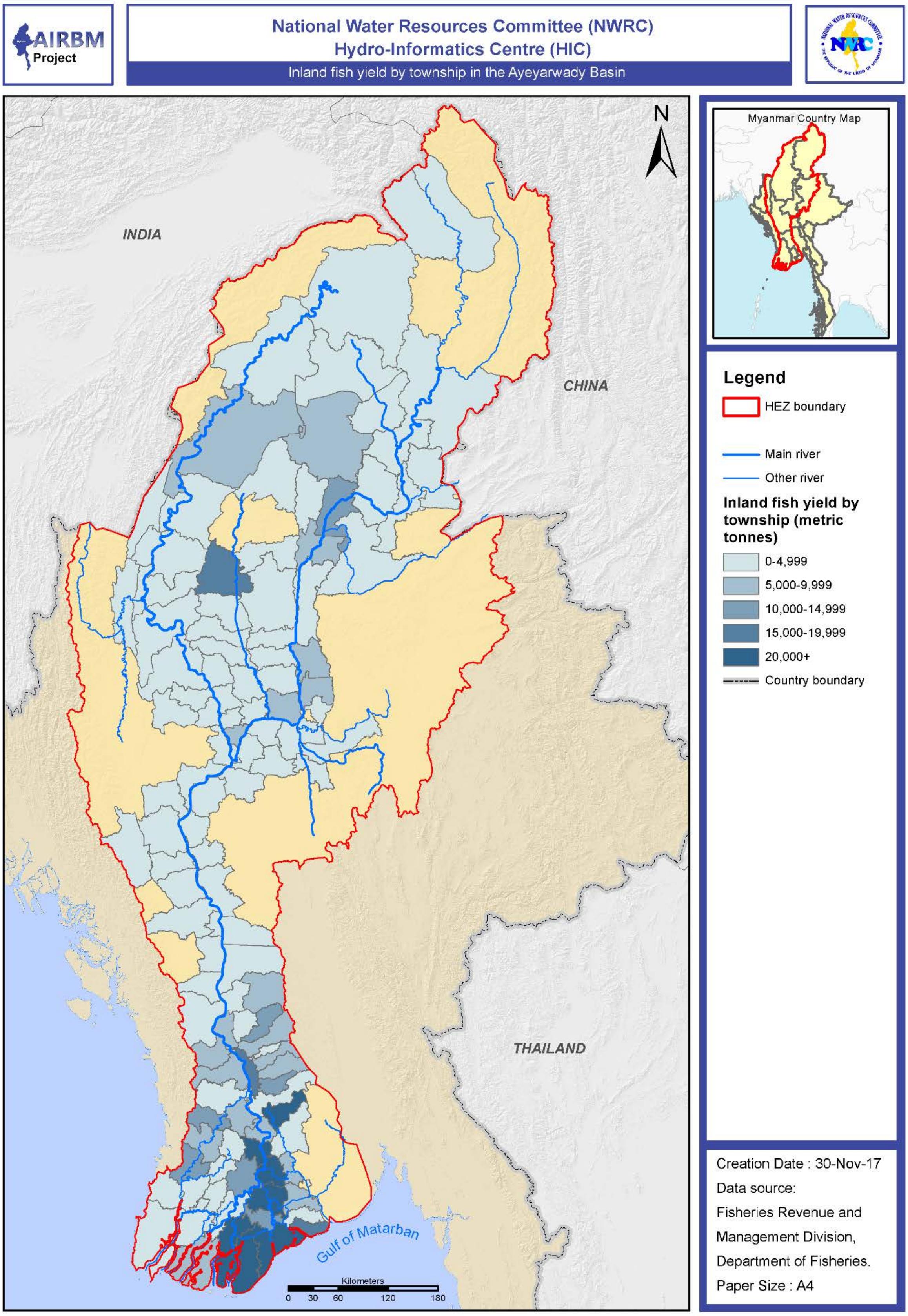


Figure 2 – Inland fish yields by township in 2015-2016: *According to statistics gathered at the township level (unpublished DoF data compiled during the assessment).*

This distribution of catches is in line with the distribution of fishing gears for registered leasable and tender fisheries in the Ayeyarwady Basin, as illustrated from the DoF township data (2015-2016 season, Figure 4).

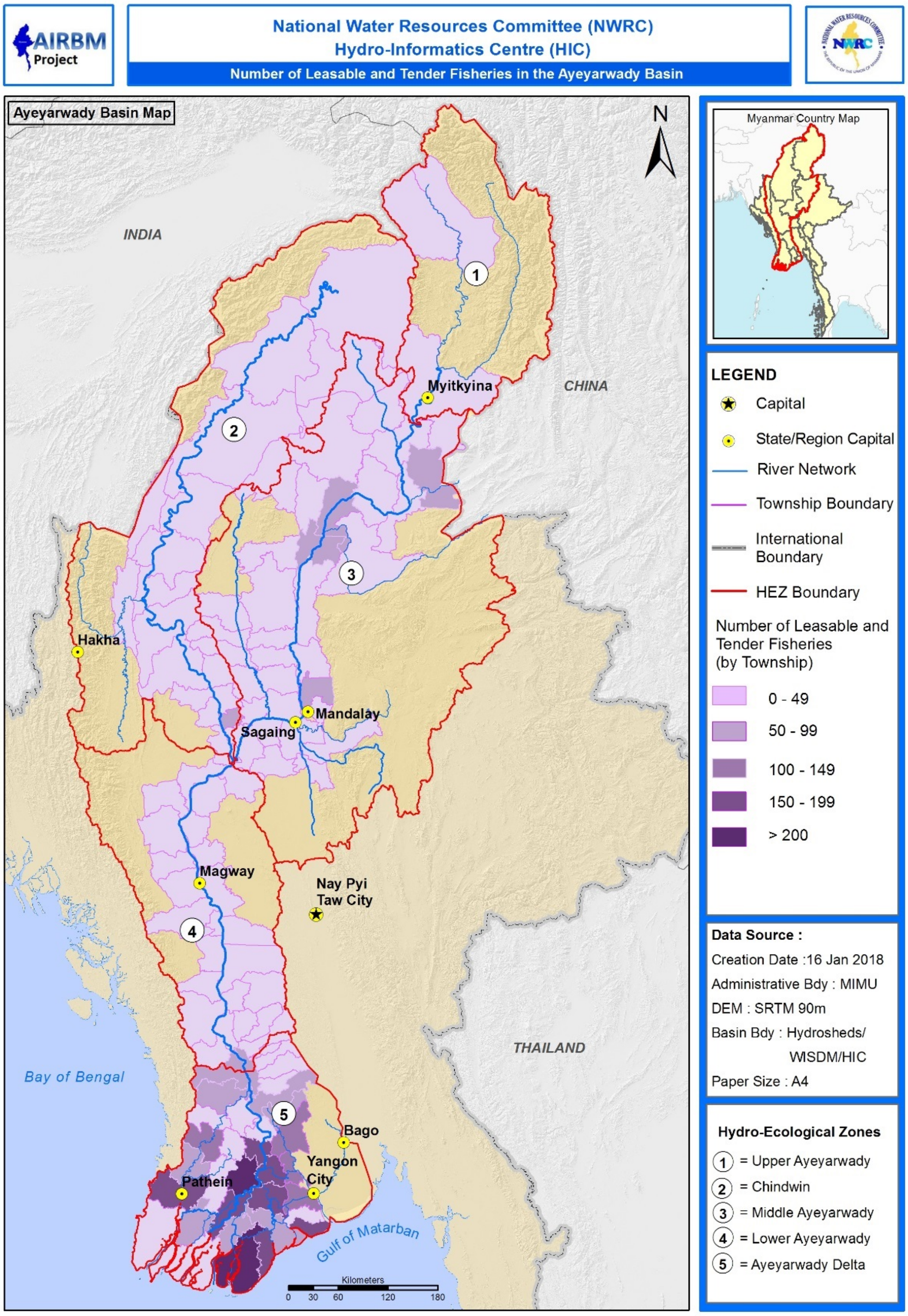


Figure 3 – Number of leasable and tender fisheries by township in 2015-2016: *According to statistics gathered at the township level (unpublished DoF data compiled during the assessment).*

These unpublished new data also give the contribution of each main type of fishery in total catch: 49% from open fisheries, 32% from leasable fisheries, and 19% from tender fisheries. For the same 2015-2016 period, statistics from the Planning Division of DoF indicate a freshwater fish yield originating 21% from leasable fisheries (tender and leases together) and 79% from open fisheries.

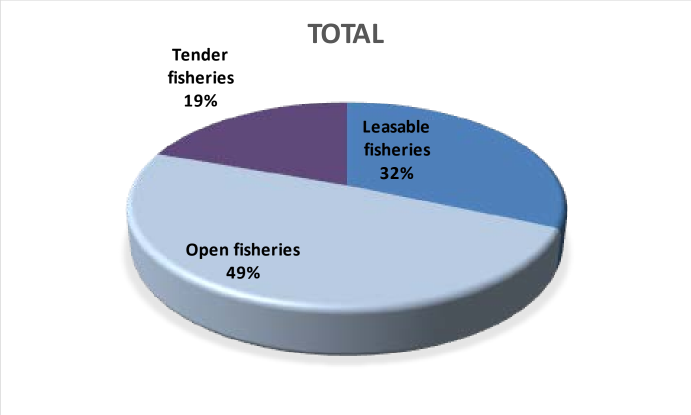


Figure 4 – Contribution of each of the main types of fisheries to the total yield in 2015-2016: *According to statistics gathered at the township level (unpublished DoF data compiled during the assessment).*

According to these data, the dominant taxon identified in catches is shrimp, followed by catfish *Wallago attu*; rohu carp *Labeo rohita*, snakehead *Channa striata*, hilsa *Tenualosa ilisha*, featherback *Notopterus notopterus*, carp *Catla catla* (now called *Gibelion catla*), catfish *Mystus spp.* and walking catfish Clarias spp..

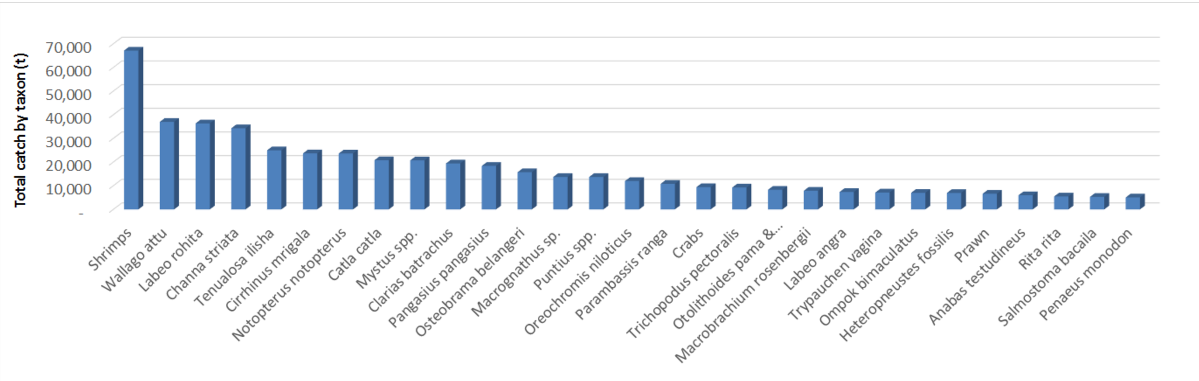


Figure 5 – Species distribution in the township data analysed: Unpublished township DoF data, 2015-2016 season. Species taxonomy reflects the original data.

There are no data that detail the monthly or seasonal distribution of catches. Similarly, data availability at the township level is such that past records of catches could not be obtained or digitized within the project time frame and that trends over years could not be assessed.

The data presented here should be carefully scrutinized, particularly when considering the following:

- The supposedly very productive fishery in Kyunhla or Homalin Townships (Sagaing District) or the relatively low fish production of the Kawhmu Township in South Yangon (such patterns are not expected in these places).
- The conflicting statistics about the respective share of leasable and open fisheries, depending on the source of data.
- The elements about reassessment of DoF data developed in the next section.

A reassessment or recalculation of the data recently received could not be done within the time frame of the current project, but it is quite possible to consider a peer-reviewed reassessment based on the expertise of DoF officers combined with external scientists, leading to either validation or amendments.

As long as biases are made constant between townships, these data can offer a very useful perspective on the spatial distribution of catches to prioritize planning and management activities in the basin.

2.3 Reassessment of Capture Fisheries Statistics in 2017

Fisheries statistics in Myanmar are characterized by on-going reassessment leading to important changes in overall catch estimates.

In 2017, a major reassessment of fish catch statistics in Myanmar led to the figure presented below (Figure 7). These figures differ from those that had been compiled before 2016, as reflected in the evolution of the Food and Agriculture Organization of the United Nations – Fisheries Global Information System (FAO FIGIS) statistics for the 2003-2014 period. Aquaculture statistics, as opposed to capture fish statistics, have not been questioned and modified.

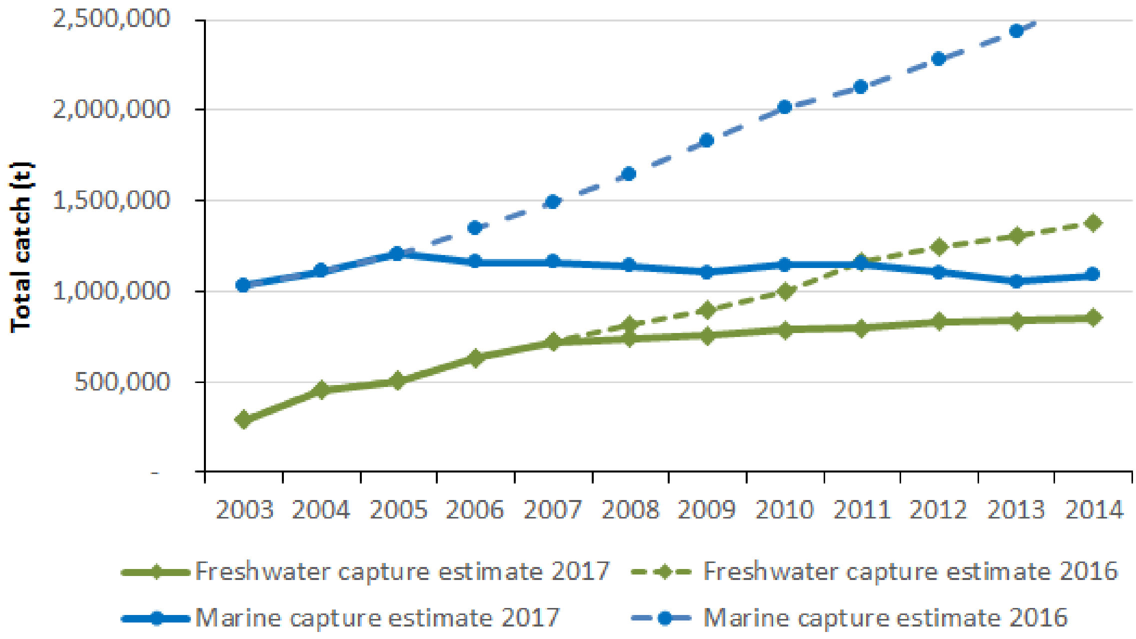


Figure 6 – Reassessment in 2017 of catch statistics from the 2003-2014 period: FAO FIGIS data in November 2016 (dotted lines) and September 2017 (plain lines)

2.3.1 *Reasons underpinning the reassessment of fish catch statistics*

The need for reassessment of capture fisheries statistics had been highlighted in recent years (Southeast Asian Fisheries Development Center [SEAFDEC], 2012; Bay of Bengal Large Marine Ecosystem [BOBLME], 2014; Hosch, 2015) due to a discrepancy between ever increasing catch statistics and evidence from field-based observations. Several reasons underpin such a discrepancy, leading to either over- or under-estimates. Annual inland fisheries yield is estimated at the township level rather than measured, accounting for a large part of the discrepancy. The estimate is based on the number of licenced gears multiplied by a constant biomass per gear (Khin Maung Soe et al., 2015). This estimate uses surface area of each leased site multiplied by a constant biomass per unit area. Depending on local productivity, the constant will vary. For other fishing gear, such as long lines, stow nets, gill nets, and traps, the constant is derived from biomass harvested per year, per gear. This approach, where actual fish catch is not measured, creates two major problems:

1. Catch statistics are indicative of number of gears, not necessarily catch. In tender fisheries, this phenomenon can incorrectly increase revenue expectations. With declining resources, each gear harvests less per unit effort, the size of individual fish decreases and the catch dwindles. However, national statistics would reflect otherwise: according to them the number of gears, and, therefore, the yield, would remain constant or perhaps increase.
2. Catch per species data are not compiled at the national level, and overall trends among individual species (e.g., hilsa and other high value species) are not available from landing statistics (e.g., top 10 species are known from export statistics, not from landings [Khin Maung Aye et al., 2006]).

In addition to the above arguments, several elements confirm the analysis:

- Between 2009 and 2014, freshwater fish landings were said to have increased by 44%, while freshwater fish exports increased by only 1%.
- During the same period, the number of full-time or part-time fishers is said to have remained almost constant.
- According to national statistics, livestock and fisheries show a quasi-constant 7.5% contribution to the Gross Domestic Product between 2005 and 2011, despite the claimed doubling of fish catches during that period.

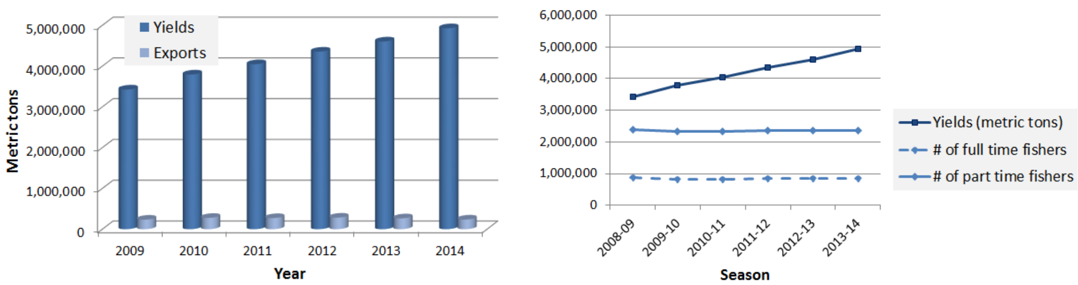


Figure 7 – Comparison of national fish yield statistics: *Comparison of fish exports (metric tons, left graph) with employment in the fisheries sector (number of people, right graph) during the 2009–2014 period (DoF data).*

2.3.2 *Historical trends in fisheries statistics*

Prior to 2000, there was limited incentive to assess and evaluate catch information, and low catch volumes recorded during this period likely reflect substantial under-reporting. For instance, inland fisheries in reservoirs and canals were not formally accounted for in official statistics. In his 2002 assessment, Coates concludes that the reported annual catch was probably underestimated by as much as 2.5 to 3.8 times (Coates, 2002).

In 2000, the government laid out a 30-year plan for fisheries development, which included total fisheries production reaching 41.5 million metric tons by 2030 (i.e., a 10% annual increase). Overall, the expectation was a 30-fold production increase over three decades. Rapid linear growth observed in officially reported catch volumes are believed to reflect these targets rather than actual production levels (BOBLME, 2014).

Around 2013, the reporting issues of the second phase started to be identified as the international community got more involved in fisheries issues. Findings from independent stock assessments and consumption surveys (Needham and Funge-Smith, 2014; Belton et al., 2015; Krakstad et al., 2014) indicate production levels far lower than those reported in national statistics. This led to the reassessment mentioned above.

The situation of the fisheries statistical system was recently reassessed in depth by the BOBLME project (BOBLME, 2014), leading to the conclusion that there seemed to be "two parallel statistical systems in Myanmar":

1. That of the Planning Division of DoF: In this system data related to total catch production "are mainly based on target levels as set by the planning organisations in their 5-10 years development plans. [...] The published results of this system most likely reflect the aspirations from the Planning Division in DoF to publish progress in the development of the fisheries and aquaculture sector, rather than real trends of the fisheries and aquaculture sector for the period 1994/95 to 2013/14. This data cannot be used to support fisheries management or policy development." (BOBLME, 2014).

2. That of the DoF at the township and district level: In this case, "some of the collected data is reliable and some is based on target level." This system includes the collection of catch statistics per species, but that information becomes unavailable at the national level. "The major constraints of this system are: 1) the system is not a standardized system for the whole of the country, there are no clear instructions and standardized data forms. Therefore, data to be provided can be interpreted in different ways", and 2) "it is almost completely paper based. No computers are available at township level" (BOBLME, 2014)

Data illustrated in Figure 2 reflect the former system, whereas those of Figure 3 reflect the latter. Data gathered from different DoF sources during the present project also exhibited significant discrepancies for the same townships or districts during the same period, which confirms the need, expressed by BOBLME (2014), for "a standardized data collection system for fisheries and aquaculture, with appropriate data collection forms, correct, and transparent raising and estimation procedures and guidelines for data collection."

2.4 Updated Fisheries Statistics

According to revised statistics, Myanmar fish production is composed of three tiers: one third inland capture fish, one third marine capture fish, and one third aquaculture fish, for a total of 2.9 million metric tons in 2015.

Below are revised national fisheries statistics as compiled by the FAO in the FIGIS system (www.fao.org/fishery/statistics/global-capture-production/query/en and www.fao.org/fishery/statistics/global-aquaculture-production/query/en).

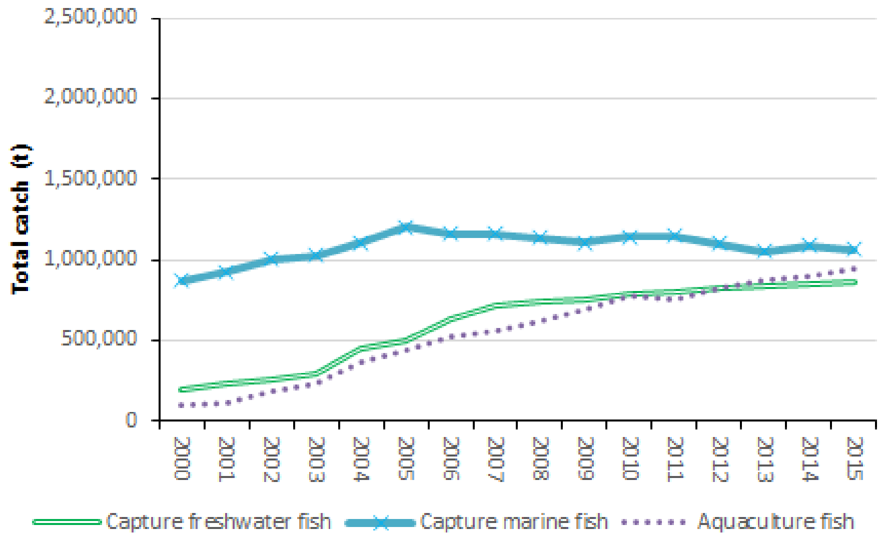


Figure 8 – Revised trends in marine capture fisheries: Freshwater capture fisheries and aquaculture between 2000 and 2015 (FAO FIGIS database query, Sept. 2017)

According to these revised statistics, Myanmar fish production is composed of approximately 863,000 metric tons or 30% of inland capture fish, 1,062,000 metric tons or 37% of marine capture fish, and 942,000 metric tons or 33% of aquaculture fish. Even downgraded from 1.58 million metric tons (former figure, see section 2.2.1) to 863,000 metric tons (revised figure, present section), freshwater fish catches in Myanmar still represent 7.2% of the world's total inland fish yield (FAO, 2016)[1].

After a peak in 2005, there has been a decline in marine fish production. This trend is reflective of the coastal and marine realms but is relevant to fisheries management in townships of the Ayeyarwady Basin.

According to the same statistics, the trend in inland fish production has plateaued, with a slow annual increase in the past decade.

In contrast to declining trends in capture fisheries, aquaculture shows a steady increase of 18% per year on average over the 2000-2015 period considered. Within the aquaculture sector, 99% of the production is from inland waters.

2.5 Fisheries Monitoring: the Way Forward

The reassessment of fisheries statistics highlights the need for tools that would ensure effective fisheries monitoring. DoF already contributes a strong administrative structure present in all townships, which is the basis for regular monitoring. The reassessment of fisheries data is based on feedback from the field and on several discrete studies whose conclusions converge. However, at the moment the reassessment is not yet based on a specific and comprehensive monitoring protocol that includes biological surveys and fishing effort assessments. More generally, monitoring the fisheries sector should also include a social component.

As identified by the Myanmar Fisheries Partnership (MFP, 2016) in its review of the inland fisheries sector:

"The way annual fishery yields are estimated leads to large biases in estimates, and data are not detailed enough to inform management (e.g. catch per species are absent in national landing statistics). A monitoring system is required at least for some target species (e.g. hilsa) to ensure sustainable exploitation. There is considerable potential in bringing together the Department of Fisheries, Universities, NGOs and the private sector for coordinated knowledge generation. The research capacity of the Department of Fisheries needs to be strengthened and a formal mechanism is required to ensure that policy and decision-makers receive and utilize updated information and scientific evidence. If no initiative is taken, knowledge of the resource will remain insufficient to protect it; the resource will remain exploited without status monitoring, i.e. until it is fishers who send a socially critical signal of overexploitation to authorities."

As detailed in the section dedicated to fisheries monitoring tools, there is a need in the Ayeyarwady for the following:

- An assessment of yields based not only on estimates per fishery but on actual sampling. Given the weight and cost of an extensive monitoring system in each township, the monitoring could be designed in a series of key townships representative of the category to which they belong.
- An assessment of the fishing effort, particularly for marine fisheries, in order to assess the evolution of the catch per unit effort.
- Monitoring species composition of the catch conducted in some monitoring sites (species present and relative abundance of each species for some target species).
- Biological monitoring of target species, at least those of specific commercial interest (such as hilsa), in order to monitor the size distribution and size at sexual maturity of individuals (i.e., two warning signals of stock overexploitation).
- Socioeconomic monitoring at the household level to assess the benefits derived from fisheries. These benefits should include income, occupational benefit, and nutritional aspects.

[1] the additional catch of the 16 fishing gear types allowed without licence in open access fisheries (see section 1.1.3) is not included in any of these statistics.

- o Monitoring of fisheries governance and effectiveness, to assess the effectiveness of the new modalities being put in place, particularly co-management modalities based on Community Fishing Groups.
- o Monitoring critical fish habitat health, following the principles of the Ecosystem Approach to Fisheries Management.

An important point to emphasize is that the different aspects of monitoring do not need to be implemented in each township but can be implemented in selected sites deemed representative of the whole system. In other words, the monitoring should be focused on generating status indicators, trends, and warning signals, rather than on producing comprehensive statistics. Developing better data collection systems to improve data quality and interpretation are critical steps to ensuring the sustainable development of the Ayeyarwady's fisheries resources.

2.6 Inland Fisheries Values: the Economic Perspective

2.6.1 Existing statistics

National statistics on fish commodities export detail three main categories: fish, prawn/shrimp, and others. According to these statistics, the total volume of freshwater, marine, and aquaculture items exported reached 338,000 metric tons from 2014 to 2015, for a total value of USD 483 million. The composition of the "other" category has evolved, with the progressive inclusion over time of bycatch (exported as fish meal), ornamental fishes, byproducts (e.g., fish maw and dried trash fish), processed byproducts (e.g., prawn shell chitin and fish scales), molluscs, cephalopods, and jellyfish. In 2010–2011, the 108 items composing the "other" category added up to 85,000 metric tons, worth USD 171 million. It should be noted that "other" fisheries products, such as molluscs, cephalopods, or crabs other than mud crabs, are not included in fisheries landing statistics.

In contrast to national statistics, SEAFDEC valued Myanmar's inland capture yields at USD 1.35 billion a year, the highest value for inland fisheries in Southeast Asia (SEAFDEC, 2012). However, when the value per metric ton is calculated, it surprisingly varies by 50% between these 2 years, which raises questions about the value calculation of fisheries products.

According to national statistics, the value of exported Myanmar inland capture fish products amounts to USD 8.5 million per year only, which is a dramatic underestimate.

DoF provides annual statistics of exported fish and fisheries products in which the respective export value of the marine, inland, and aquaculture subsectors are detailed (e.g. DoF 2011b, 2013). An averaging of the volume and value of exports for 2009–2012 shows that inland fisheries are supposed to contribute only 1 to 3% of total exports. We believe that exports of Myanmar inland capture fish products are largely underestimated due to a classification issue. Actual figures reach at least USD 60 million per year (i.e. 10% of national fishery exports). In particular, specific freshwater fisheries items of high value, such as eels, dried gourami, and freshwater prawns (as well as ornamental fish species and others), are classified under the "other" export category. For this reason, the contribution of all inland fisheries products is not fully reflected in current national fisheries statistics. Khin Maung Soe et al. (2015) show that adding three freshwater export commodities (eels, gourami, and freshwater prawns) to the category of inland fisheries products in export statistics would multiply the value of inland fisheries products by five.

2.6.2 *Fish value chains*

Five main fish value chains can be distinguished in Myanmar:

- Fresh fish supply chain, including for the fishers' own consumption. This value chain usually involves small quantities and low profit margins, but it plays a crucial role in the food security of the poorest consumers and fishing communities.
- Dried and processed fish chain – essential for the food security of upland areas in Myanmar where processed fish is often the only source of fish.
- Urban fresh fish chain – a relatively new but fast-growing chain driven by traders (small-scale fishers do not have the financial resources, infrastructure, and market information to play a direct role in transactions beyond the local level).
- Animal-feed chain – a flourishing exploitation and transformation chain despite frequent spoilage due to poor preservation, processing, and transportation. Small-scale fishers contribute to the supply of fish.
- Export value chain – by far the most lucrative value chain. Fishers' involvement is limited to providing fish or working in processing activities.

Considering the fish catches it handles and the income it generates, Venkatesh (2015) considers the urban fresh fish market to have the highest potential for small-scale fishers. Enhancing the role of small-scale fishers in these value chains will require interventions on several fronts:

- Facilitate fishers' access to fish resources and structuration aimed at increasing the volume of fish proposed to directly reach higher levels in the value chain.
- Improve infrastructure conditions (landing, preservation, and transportation) to ensure good fish quality up to the end consumer.
- Strengthen fishers' bargaining capacity and reduce their dependence on traders (through community institutional development, access to ice and markets, and to credit).
- Build the capacity of staff of relevant government agencies (e.g., DoF).
- Promote sustainable and equitable fisheries policies.

3 ECOLOGY OF FISHERIES RESOURCES

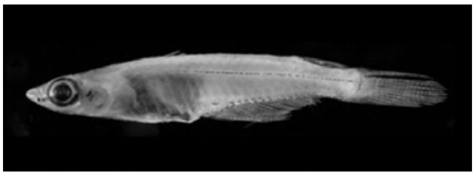
3.1 Diversity of Fish Resources

As detailed in a companion report (SOBA 4-05: Biodiversity of the Ayeyarwady Basin), the overall number of fish species recorded in the Ayeyarwady Basin is 388, of which 311 are present in Myanmar while the others are found in India and China. Among the 388 fish species, 193 (50%) are endemic to the basin, and 100 (26%) of the endemics are presently only found in Myanmar.

Local species lists gathered during the assessment in DoF township offices allowed compiling an overall list of 514 species in 60 families. However, checking and validating the taxonomic accuracy of this list by examining samples and cross-checking each species using existing literature would have require more time than was compatible with the time frame of this project.

The largest species found nationally is the panga catfish *Pangasius pangasius*, (maximum recorded length of 3 metres (m) and 248 kilograms. The smallest species is the rice field fish *Oryzias uwai*, at only 1.6 cm in length. The longest-living fish in the system is the catfish *Rita sacerdotum* (Figure 10); this fish has been recorded to live 58 years (FAO, 2014).

Pangasius pangasius. Photo: Rahman, A.K.A



Oryzias uwai. Photo: Parenti, L.R

Rita sacerdotum. Photo: Nonn Panitvong

Figure 9 – Some fish species of note from Myanmar

Fishers exploit almost all these species, particularly focusing on migratory species.

3.2 Documented Fish Migrations

Large and migratory species of commercial significance, such as catfishes (*Wallago attu* and several Pangasius species), that have become rare in most tropical rivers, even in the Mekong, are still relatively abundant in Myanmar rivers. However, stakeholders interviewed in the Central Dry Zone unanimously reported declining abundance in such species and attributed this to pollution, changes in sediment load, and illegal fishing. No change in species size or composition was reported (Johnstone et al., 2013).

The migratory status of 30 species was recently surveyed through the Ayeyarwady Delta and Central Dry Zone (Win Ko Ko et al., 2016). Migration routes, temporal patterns, abundance, and breeding sites were identified for 12 species in particular (*Catla catla, Cirrhinus cirrhosus, Hilsa kelee, Ilisha megaloptera, Labeo calbasu, Lates calcarifer, Pangasius sp., Pangasius pangasius, Rita sp., Silonia silondia, Tenualosa ilisha,* and *Wallago attu*). This study, based on local ecological knowledge, is the most comprehensive recent study of fish migrations in the Ayeyarwady Basin, and its results are presented below.

Forty-two sites within 37 townships, covering all the major rivers of the delta (Figure 2) and the main rivers of the Central Dry Zone (Figure 3), were surveyed between December 2013 and December 2014. The rivers surveyed and the study sites are illustrated in Figure 11.

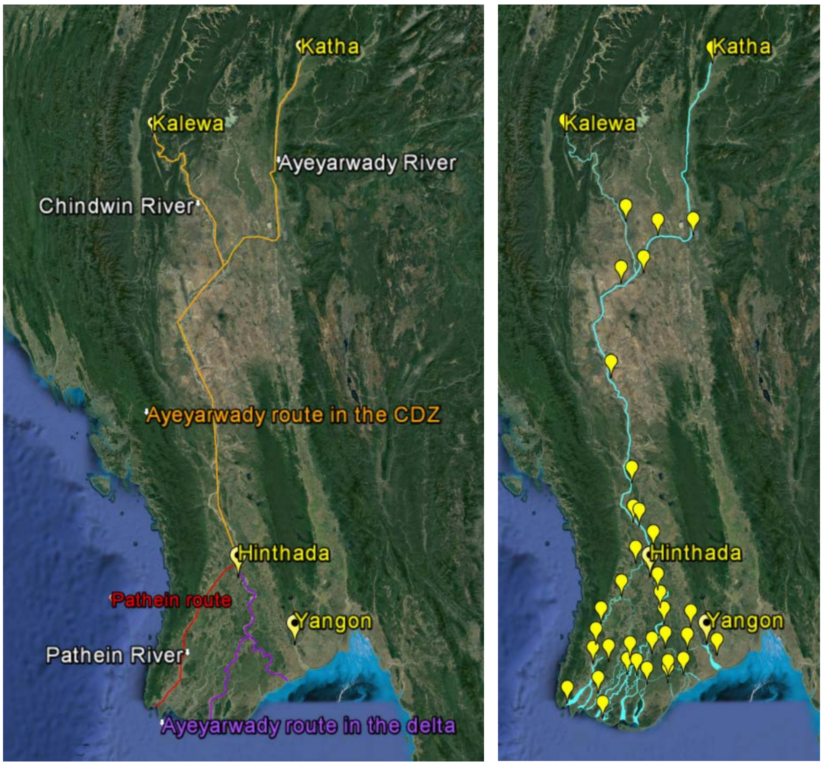


Figure 10 – Rivers surveyed and sites surveyed in the Ayeyarwady system

The 200 fishermen interviewed do not know the migratory status of 14 species. Most of these species are quite rare and have no known breeding sites in the places surveyed. These species include: *Anguilla sp.* and *Anguilla bicolor* (caught but not abundant), *Anodontostoma chacunda, Bagarius yarrelli, Chaca burmensis, Macrognathus zebrinus, Pangasianodon hypophthalmus, Pangasius larnaudii, Raiamas guttatus, Tenualosa toli,* and *Pristis microdon* (rare species). The migratory status is also unknown for *Cyclocheilichthys apogon, Mastacembelus armatus,* and *Monopterus cuchia*, although these species are not particularly rare.

For the other species, average monthly catch per fisherman is much higher in the delta than in the Central Dry Zone. The five migratory species dominant in catches are *Pangasius sp., Tenualosa ilisha, Rita sp., Pangasius pangasius,* and *Hemibagrus microphthalmus*. Three out of five are catfishes. These top-five species are followed by species that are not abundant but remain common, particularly during their migration period. They include *Wallago attu, Cirrhinus cirrhosus/mrigala, Bagarius bagarius, Catla catla, Labeo calbasu, Sperata sp.,* and *Silonia silondia*. The remaining species (*Gudusia variegata, Lates calcarifer, Bagarius yarrelli, Hilsa kelee, Ilisha megaloptera, Macrognathus zebrinus, Pangasianodon hypophthalmus,* and *Mastacembelus armatus*) are rare in catches. The monthly abundance patterns of these species are detailed in Figure 12.

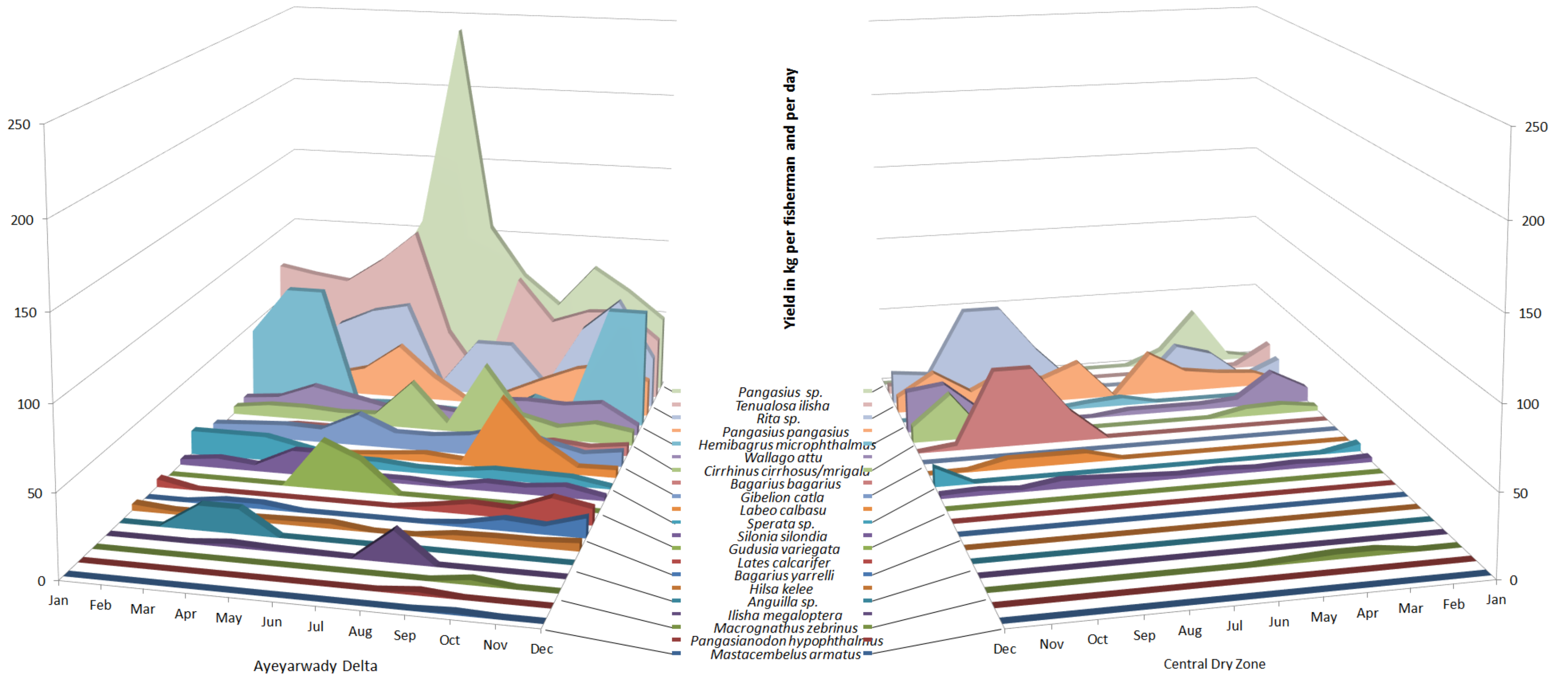


Figure 11 – Monthly distribution of yield in kilograms per fisherman and per day in the Ayeyarwady Delta (left) and in the Central Dry Zone (right)

25

Among these species, two are considered to be migratory with no known breeding sites (*Hilsa kelee* and *Ilisha megaloptera*). Six species are considered non-migratory, but their breeding sites in the Ayeyarwady system are known (*Bagarius bagarius, Cirrhinus mrigala, Gudusia variegata, Hemibagrus microphthalmus, Pangasianodon gigas, and Sperata sp.*). Last, there are nine migratory species whose breeding sites are also known (*Catla catla, Cirrhinus cirrhosus, Labeo calbasu, Lates calcarifer, Pangasius sp., Pangasius pangasius, Rita sp., Silonia silondia, and Wallago attu*).

Two species are characterized by a high number of breeding sites in multiple townships. These species are *Tenualosa ilisha* (hilsa) and *Wallago attu* (whiskered catfish). Conversely, six species are characterized by a limited number of known breeding sites (1 to 3 maximum). These species include the following:

- *Bagarius bagarius, Gudusia variegata* and *Pangasianodon giga*s (one breeding site)
- *Sperata sp.* (two breeding sites)
- *Hemibagrus microphthalmus* and *Silonia silondia* (three breeding sites).

These six species require special attention in terms of management through the protection of their breeding sites. Hinthada, in particular, is a township where three of these species breed.

The breeding sites of 14 migratory species in 42 townships are detailed in Table 3**.**

The study also features an analysis of zones based on their ecological value from a fisheries protection perspective. This ecological value is a combination of number of species breeding, surface area of breeding sites, and importance of species to fisheries. Results show that Hinthada Township features the highest ecological value, with large spawning sites for 9 species, most of them being commercially valuable. Consequently, Hinthada Township is a priority place for fisheries resource protection and management measures.

The townships that feature the second highest ecological value are Ingapu, Myanaung, Yandoon, and Twantay. Nine townships – Hainggyi, Kyaiklat, Labutta, Mandalay, Myingyan, Ngapudaw, Pathein, and Pyinzalu – feature no breeding sites and therefore have low ecological value.

Table 3 – Breeding sites of 16 species in 42 townships

	Bogale	Dadaye	Danubyu	Hainggyi	Hinthada	Htantabin	Ingapu	Kalewa	Kathar	Kyaiklat	Kyangin	Kyauktan	Kyonemangay	Labutta	Lemyethna	Magway	Mandalay	Maubin	Mawgyun	Monyo	Monywa	Myanaung	Myangmya	Myingyan	Myinmu	Ngapudaw	Pathein	Pokokku	Pyapon	Pyay	Pyinzalu	Shwe Taung Hmaw	Thabaung	Twantay	Wakema	Yandoon	Yegyi	Zalun	Kyaik Hto	Sit Taung	Sut Pa Nu	Thein Za Yat
Bagarius bagarius																														✓												
Catla catla					✓		✓	✓			✓									✓		✓												✓	✓	✓	✓	✓				
Cirrhinus cirrhosus			✓				✓															✓												✓		✓	✓	✓				
Cirrhinus mrigala					✓		✓	✓	✓											✓																						
Gudusia variegata					✓																																					
Hemibagrus microphthalmus							✓															✓			✓																	
Labeo calbasu					✓		✓	✓	✓									✓				✓						✓								✓						
Lates calcarifer	✓	✓																	✓										✓										✓		✓	
Pangasianodon gigas																																		✓								
Pangasius conchophilus											✓	✓																						✓		✓						
Pangasius pangasius					✓	✓																✓							✓					✓					✓			
Rita rita																						✓								✓								✓				
Silonia silondia					✓													✓																		✓						
Sperata aor					✓																																	✓				
Tenualosa ilisha					✓		✓				✓	✓	✓		✓	✓		✓		✓	✓	✓	✓					✓				✓	✓	✓	✓	✓	✓	✓		✓		✓
Wallago attu					✓		✓	✓	✓		✓							✓	✓			✓			✓			✓					✓	✓		✓		✓			✓	✓

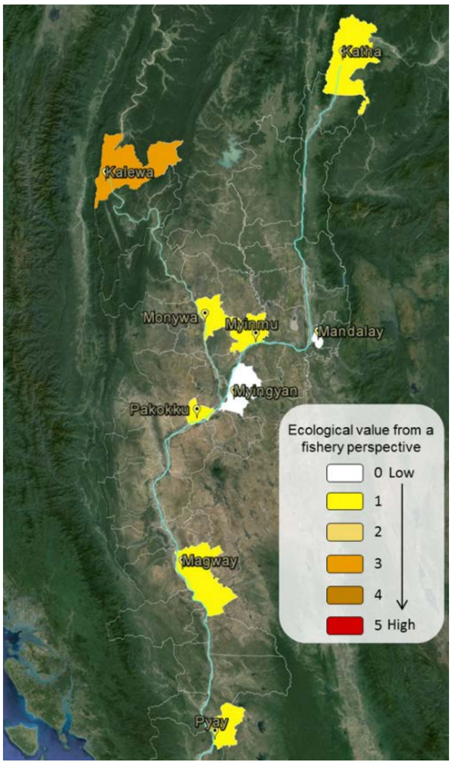


Figure 12 – Ecological value of townships in the Central Dry Zone from a fish resource protection perspective

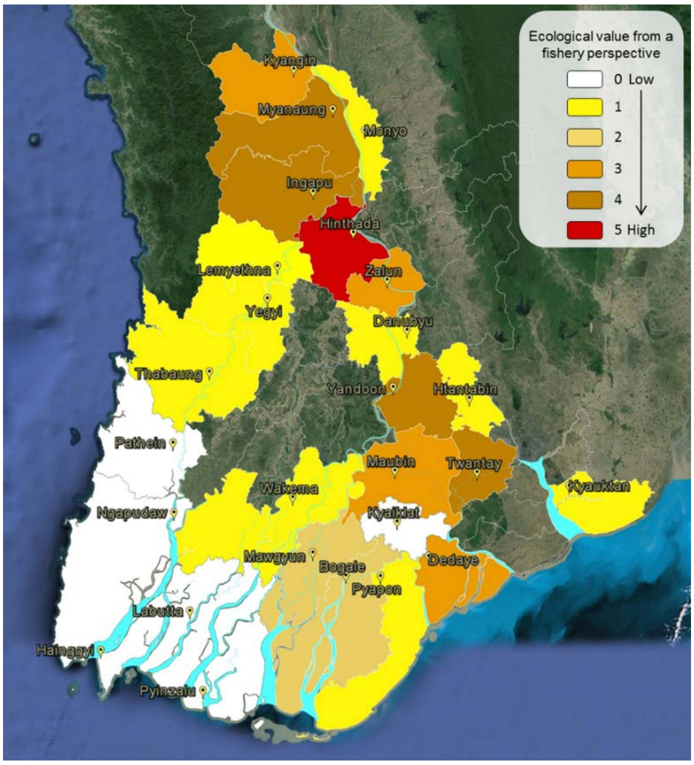


Figure 13 – Ecological value of townships in the Ayeyarwady Delta from a fish resource protection perspective

3.3 The Case of Hilsa Migrations in the Ayeyarwady System

Hilsa (*Tenualosa ilisha*) is of particularly high commercial value and is a major migratory fishery resource in the Gulf of Bengal, with stocks shared between multiple countries and breeding migrations in rivers, including in the Ayeyarwady. We present below the results from a study undertaken in 2014 about the migration and breeding sites of this species (Baran et al., 2015).

In the Ayeyarwady Delta, there is no fishing from July to August, which is the monsoonal or flooding season. In general, the greatest abundance and yield of hilsa is from October to May. The coastal zone shows a consistently high yield throughout the year. This zone is characterized by adult fish rather than by juveniles. Juveniles are observed inland as well as large-sized individuals (probably breeders).

Along the Pathein River, abundance is highest and largely constant at the mouth of the river. Abundance decreases with distance from the sea, as does the size of the individuals. Large individuals migrate upstream in the first half of the year, while smaller individuals migrate upstream during the second half (Figure 15).

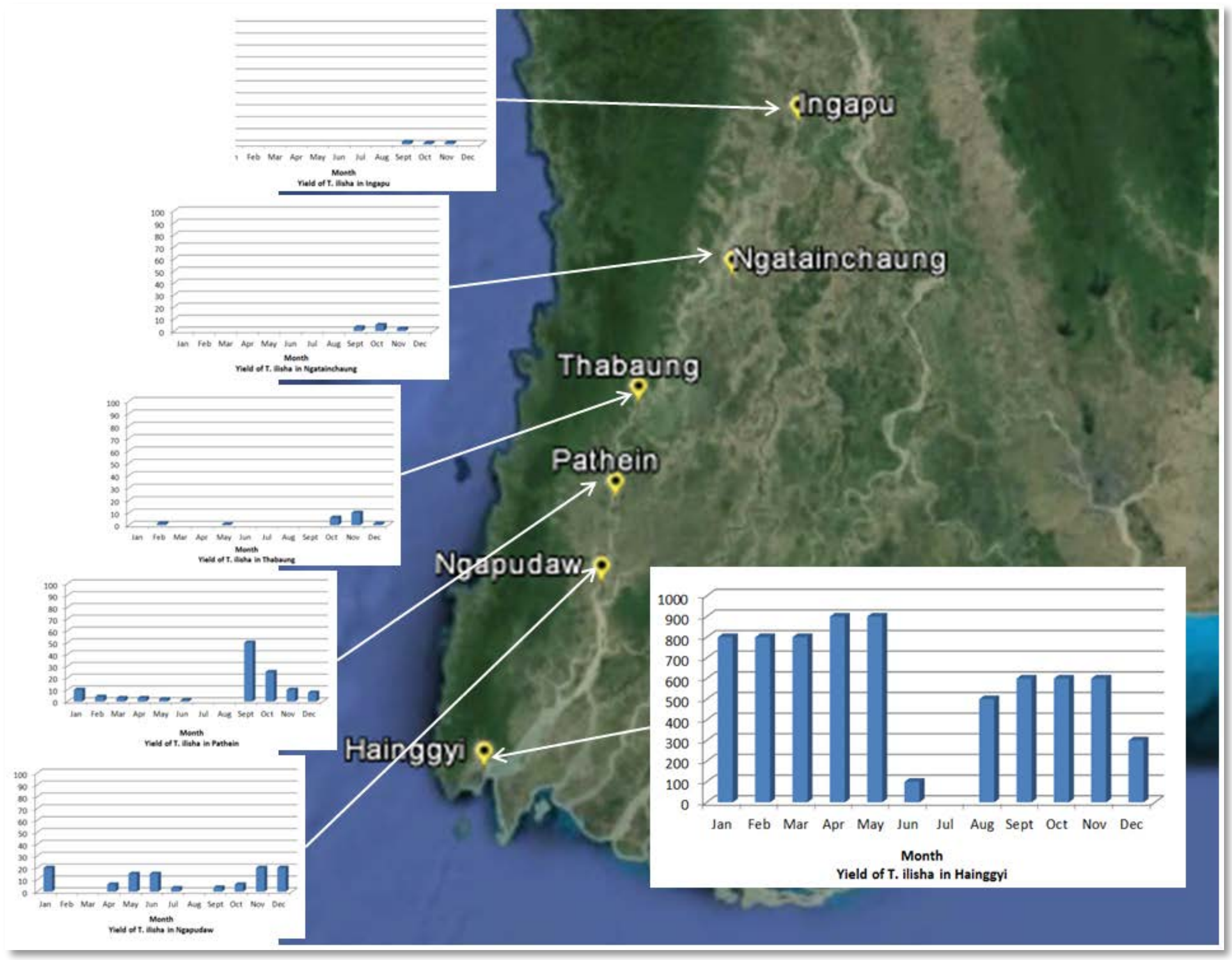


Figure 14 – *Spatio-temporal patterns of hilsa abundance along the Pathein River*

Along the Ayeyarwady River, the following four patterns of hilsa abundance and distribution were identified:

1) Relatively high abundance along the coast and in estuaries that are large and close to the river's mouths. Hilsa is found throughout much of the year in these areas.
2) Away from the coast and in smaller rivers the abundance is low and diminishes in proportion to the distance from the coast.
3) Dedaye and Twantay displayed a usually high abundance compared to other estuarine sites. They are located on the Toe River and linked to the Yangon River by the Twantay Canal, which are two important migration routes.

4) Upstream of the confluence of the Ayeyarwady and Toe Rivers, hilsa abundance is consistently high up to Hinthada, then suddenly drops (Figure 16).

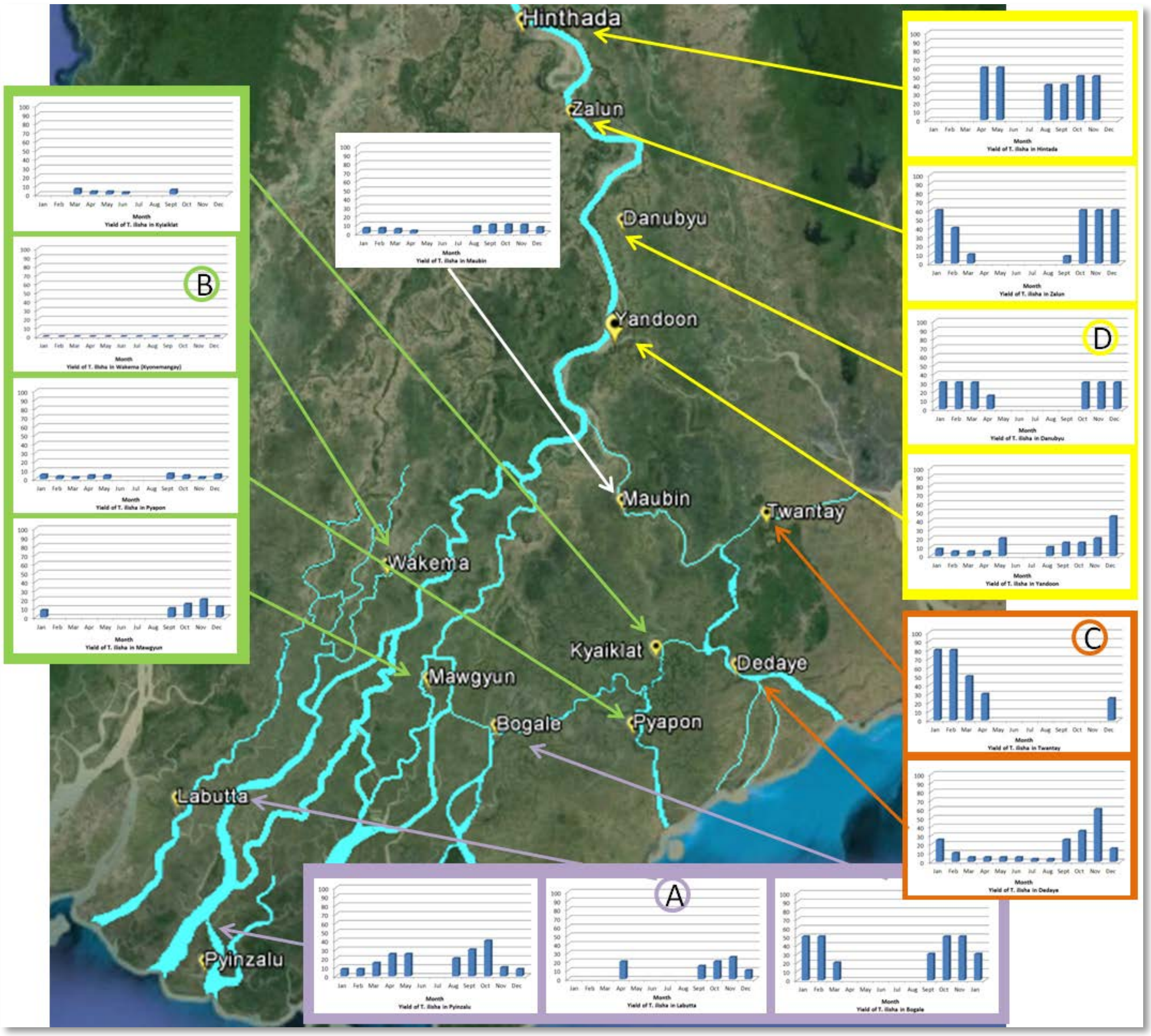


Figure 15 – Spatio-temporal patterns of hilsa abundance along the Ayeyarwady route in the delta

Hilsa breeding sites were identified in 15 out of 32 locations surveyed, with the largest breeding site found around Hinthada Township, which is located 230 to 310 kilometres from the sea. The results indicate that the section centered on Hinthada and stretching from Zalun to Monyo is the most important hilsa breeding zone in the Ayeyarwady system.

The Baran et al.'s study indicates that the Ayeyarwady mainstream is the most important migration route to upstream breeding sites. However, the important contribution of the Toe River and Twantay Canal should be noted. It is the convergence of these three migration routes that probably contributes most to breeding and sustainability of the stock.

An overview of main migration routes in the Ayeyarwady Delta is presented below:

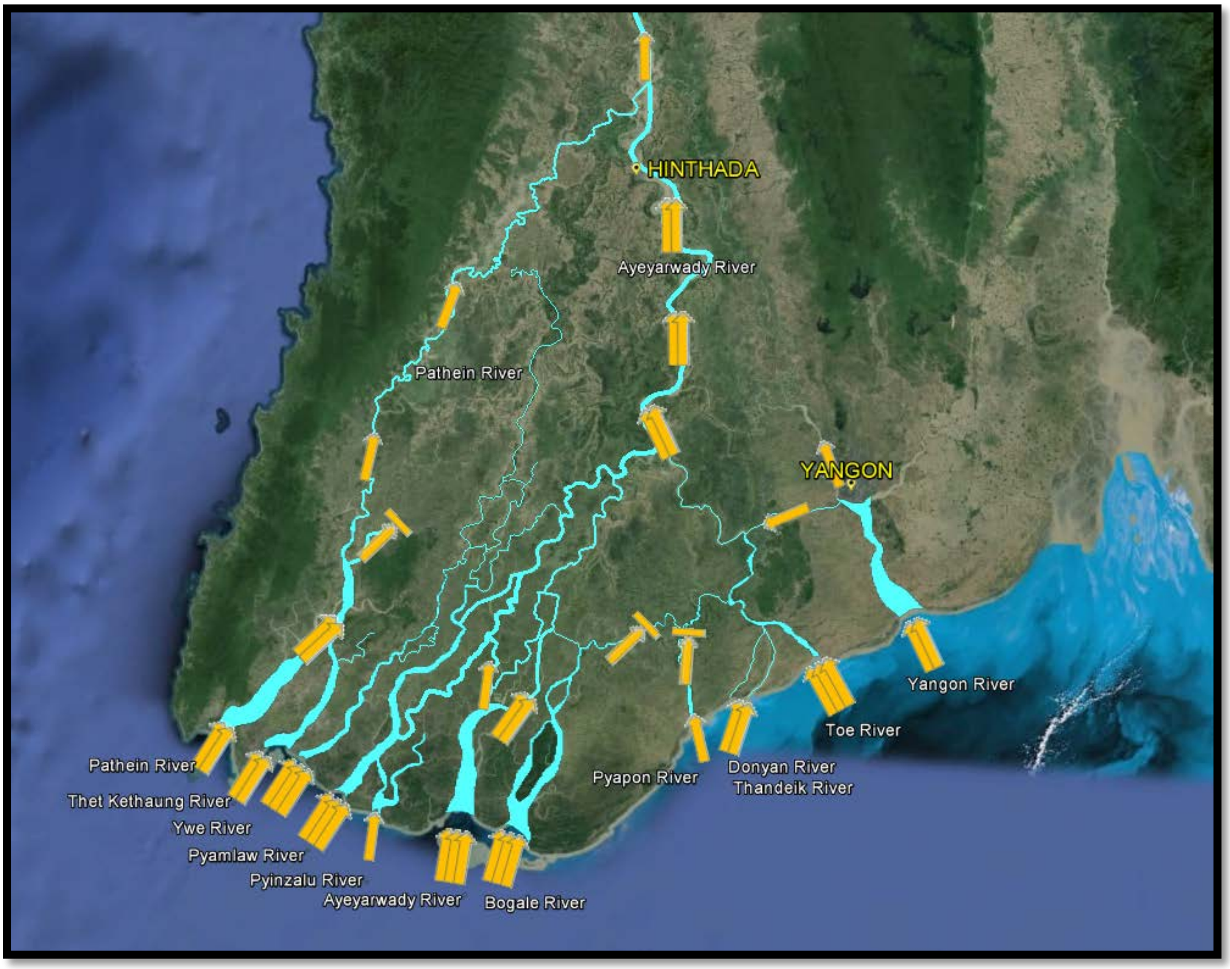


Figure 16 – *Summary of hilsa migration routes in the Ayeyarwady Delta*

The study makes the following two main recommendations:

1. Given the importance of the convergence point of the Toe River, Twantay Canal, and Ayeyarwady mainstream to the migration and breeding of hilsa, this site should be a priority location for protection and regulation measures.
2. The section of the Ayeyarwady centered on Hinthada and stretching from Zalun to Monyo is the most important hilsa breeding zone and should also be considered a priority location for protection and regulation measures.

3.4 The Threat of Climate Change

Myanmar is believed to be one of the countries most vulnerable to climate change on a global basis (World Bank Group [WBG], 2014), and, excluding small island states, the most vulnerable in the Asia-Pacific region (Centre for Global Development [CGD], 2014). This status takes into account physical risks and the country's expected coping capability.

Multiple studies downscaled to the regional and national levels indicate that Myanmar is projected to experience a mean annual temperature increase of between 1 degree Celsius (°C) and 4°C by the end of the century, with variability throughout the year and spatially across the country (Kye Baroang, 2013). Myanmar's mean annual temperature has been rising over the past few decades, and the country is already experiencing increased climate variability, notably with rainfall (WBG, 2014). The continued increase in temperature is expected to be accompanied by more variable rainfall and the possibility of more extreme climate events, such as cyclones (Kye Baroang, 2013). All of these trends have implications for fisheries, including the following:

- Higher inland water temperatures may reduce the availability of wild fish stocks by degrading water quality, introducing new predators and pathogens to the ecosystem, and changing the abundance of food available to fishery species.
- Changes in rainfall may lead to changes in fish migration and recruitment patterns and success.
- Drought may lead to reduced wild fish stocks, intensified competition for fishing areas, and more migration by fishers and their families.
- Rising sea level may lead to salt water infusion, incurring alteration to freshwater capture fisheries, as 10% of the country is projected to be affected by a sea-level rise of 1 to 5 m (WorldFish, 2017; WBG, 2014) – even though marine or estuarine species might replace freshwater ones in these zones.

The challenges posed by climate change will require early decision making about adaptation strategies to minimize the impacts on the livelihoods and food security of the poorest fishers, in particular (Schmidt and Khin Maung Soe, 2015). As stated by FAO (2010), "Climate change and the increasing incidence of severe weather episodes will place fishing communities and their investments in physical infrastructure and aquaculture biomass at risk and will require long-term adaptation strategies."

4 FISHERIES LIVELIHOODS

4.1 Livelihoods and Employment

Fisheries contribute significantly to employment in Myanmar, providing jobs for approximately 3.2 million people (2.4 million part-time jobs, and 800,000 full-time jobs). There are marginally more part-time work opportunities in inland fisheries (1.6 million) compared to marine fisheries (1.4 million). Average job distribution from 2013 to 2014 is depicted in Figure 18.

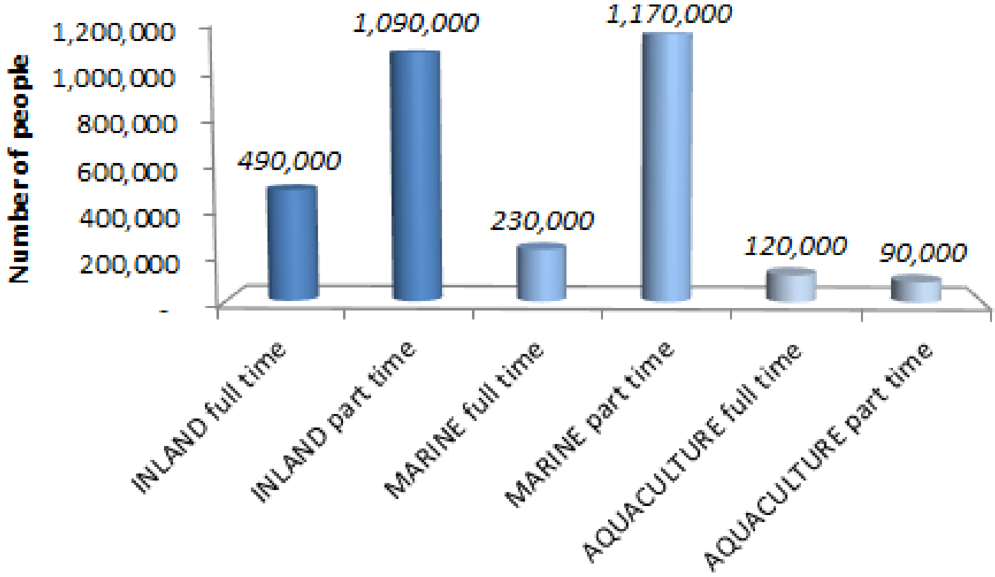


Figure 17 – Number of people involved in aquaculture and capture fisheries (2008 to 2014 average) (*DoP, 2015)*

Accounting for approximately 70% of total employment, agriculture is a major source of livelihood in Myanmar. As the second largest contributor to income generation, employment, and livelihood (DoF, 2015; Schmidt and Khin Maung Soe, 2015), the fisheries sector also contributes substantially to socioeconomic and cultural aspects of life in Myanmar (Win Oo, 2002; Asian Development Bank [ADB] 2013). In Myanmar, approximately 12 to 15 million people generate income through fisheries (McCartney and Khaing, 2014). Per acre, fish farming produces an estimated two times the employment compared with paddy farming (Belton et al., 2015). For 25% of landless households, primary sources of income come from fisheries through wage labor or fish sales (Livelihoods and Food Security [LIFT], 2012b). More broadly, the fisheries sector is estimated to provide income for 12 to 15 million people in Myanmar (McCartney and Khaing 2014).

Reliance on fisheries for livelihood differs between geographic regions in Myanmar. Fisheries contribute to livelihoods in the delta region much more significantly than in the Central Dry Zone. Table 4 outlines key characteristics of both regions in relation to livelihood.

Table 4 – Relationship of fisheries to livelihoods in the Ayeyarwady Delta and in the Central Dry Zone

Ayeyarwady Delta	Central Dry Zone
In 2013, a study looking at 136 small-scale aquaculture households in the Ayeyarwady Delta found similar contributions of rice and fish to the household's income (29.8% and 27.6%, respectively) (MYFish, 2014).	Characterized by water constraints, there are limited opportunities for fisheries in this zone (Johnstone et al., 2013).
There is a substantially higher reliance on wage labor between agriculture and fisheries in this region. Casual or wage labor was reported as the primary source of income in 19% of households in a 2013 survey (this figure likely includes aquaculture; MYFish, 2014). Some communities rely almost entirely on fishing for income generation and subsistence. Moreover, hilsa represents a major part of fisher family incomes in freshwater (77%) and in brackish and saline water (up to 97%) (Myanmar Marketing Research and Development [MMRD], 2015).	Only 2% of families were engaged in fishing as a livelihood activity (Ah Poe, 2011). According to a LIFT survey, only 0.5% of households considered freshwater fishing to be their most important source of livelihood and 0.4% of households regarded casual labor in fisheries to be their most important source of income (LIFT, 2013).
Twenty-three percent of households regard the sale of fresh wild fish, prawns, crabs, and shellfish as one of their primary sources of income in 2013 (LIFT, 2013). Fifty-four percent of households identify fisheries (direct and wage labor) as an important source of income (LIFT, 2013).	Agricultural labor contributes to nearly three quarters of households' primary income source (LIFT, 2012b).

4.2 Fish, Nutrition, and Food Security

In a 2010 World Bank report, 17% of households reported to be food insecure. Approximately 25% to 33% of children in Myanmar are underweight, 40% of children under the age of five are stunted, and 7.9% to 11% are wasted (LIFT, 2013; Thilsted and Bose, 2014). Myanmar is ranked 32 out of 136 countries for prevalence of stunting (MYFish, 2014).

Chin State has the highest rates of food poverty, with approximately 40% of the population suffering from food poverty (Shwe and Hlaing, 2011; based on a 2007 study). Shan State is second to Chin State in terms of the proportion of its population suffering from food poverty. The Dry Central Zone has approximately 30% stunted or underweight children under 5 years of age (Ministry of National Planning and Economic Development [MNPED] et al., 2011). In the Magway and Mandalay regions, a study of 630 households found that 17% of households were severely food insecure and 24% were moderately food insecure (Ah Poe, 2011). In 2010, rates of food insecurity were approximately 17% in the Ayeyarwady Delta (World Bank, 2010). Here, 30% of children under 5 years of age are underweight and approximately 30% are stunted (MNPED et al., 2011).

4.2.1 *The role of fish*

Second only to rice, fish is a major contributor to Myanmar's national diet (WorldFish, 2014). Fish is rich in essential micronutrients, such as calcium, iodine, and some vitamins, as well as amino acids and oils. Consuming fish also contributes to the bioavailability of micronutrients from other food items in the meal (Vilain and Baran, 2016).

Fish accounts for approximately 60% of animal protein intake in Myanmar (Wilson and Wai, 2013) and provides an important source of micronutrients for the population. The average person's calorie intake is less than half of the World Bank's recommended standard (Belton et al., 2015).

Fish and fish products (i.e., fish sauce and fish paste) are additional desirable food products for people in the basin. Fermented fish are a staple in the daily diet of the majority of people in Myanmar (Aung Htay Oo, 2010). Even in coastal areas, people generally prefer freshwater fish to marine fish for consumption (Win Oo, 2002; DoF, 2011a; Thilsted and Bose, 2014).

4.2.2 *Fish consumption*

In 2000, consumption of fish per capita was estimated to be triple the amount of meat consumption for the population (FAO-NACA, 2003). There is limited raw fish availability during the dry season in Myanmar, and dried fish is more commonly consumed as a substitute during this time (Thilsted and Bose, 2014). Various fish and fish product consumption (fish paste, dried fish, and fermented fish) exceeds other animal protein source consumption (meat and egg) by a scale of 10 to 1 (FAO-NACA, 2003).

There is a lack of documentation on the inter-regional differences in fish consumption (WorldFish et al., 2014). A survey of 150 households across 6 villages conducted in the Labutta and Bogalay Townships of the delta (MMRD, 2014) showed that 54% of fishing households consume half their catch and 13.5% of households are completely dependent on food from household fish catch. Some figures depict much higher fish consumption in the Ayeyarwady Delta than in the Central Dry Zone, with 83% of coastal and delta zone households eating fish and/or seafood the day prior to the survey, compared to only 27% in the Central Dry Zone (LIFT, 2013).

Many families in the Central Dry Zone collect aquatic resources seasonally to obtain their daily nutrients (Johnstone et al., 2013). Assuring availability and access to fish supplies is critical to food and nutrition security in Myanmar (Belton et al., 2015).

Due to a lack of dependable statistics reporting national fish consumption, a variety of tools have been used to approximate average per capita fish consumption in Myanmar. Table 5 provides a brief outline of various fish consumption reporting in Myanmar.

Table 5 – Several Myanmar consumption statistics with source and year

Fish Consumption	Year	Department	Reference
15.12 kilogram (kg) per person per year (based on a household survey).	2001	MNPED	Khin Maung Soe, 2008
28.45 kg per capita.	2001 to 2002	Ministry of Livestock and Fisheries	Burgos et al., 2009
1,138,865 metric tons available for national consumption (or 22.7 kg per person per year). (FAO suggests that this figure could be closer to 26 to 34 kg if likely unreported fishing is accounted for.)		FAO and DoF	FAO-NACA, 2003
Consumption rate of 43 kg per person per year (similar to the SEAFDEC estimate of 42.75 kg for the same year).	2008 to 2009	SEAFDEC	Aung Htay Oo, 2010; SEAFDEC, 2012
Per capita consumption rate of 61 kg per year (this calculation reflects landings minus non-food use minus exports, all divided by Myanmar's population).		DoF	DoF, 2015

National statistics of fish consumption are based on the following formula: [Landings – Exports] / Population. A discount of 20% was introduced in 2007-2008 for "non food uses." In fact, national fish statistics regarding fish consumption are rough and inaccurate. They cannot be used for monitoring in the Ayeyarwady Basin. The relationship between Myanmar's population and fish consumption (MMRD, 2010) demonstrates the flaw in statistics as it implies a fish consumption growth of more than 100% between 2002–2003 and 2007-

2008. Some of this unrealistic growth in official fish consumption figures can be attributed to significant underestimates of fish exports, majorly biasing the local consumption calculation.

Inconsistency in fish consumption studies as well as the unrealistic growth portrayed in fish consumption patterns require large-scale and rigorous reassessment in Myanmar.

4.2.3 Species

Table 6 lists the primary inland fish species consumed in Myanmar (Thilsted and Bose, 2014).

Table 6 – Primary inland fish species consumed in Myanmar *(Source: Thilsted and Bose 2014)*

	English Name	Local Name	Latin Name
Small fish	Climbing perch	Nga pyaema	*Anabas testudineus*
	Mola carplet	Nga bae phyu	*Amblypharyn-godon mola*
	Pool barb	Nga khone ma mee ni	*Puntius sophore*
	Spotted snakehead	Nga pa naw	*Channa punctata*
	Striped dwarf catfish	Nga zin yine	*Mystus vittatus*
Medium fish	Bronze featherback	Nga phae khone	*Notopterus notopterus*
	Philippine catfish	Nga khu	*Clarias sp.*
	Stinging catfish	Nga gyee	*Heteropneustes fossilis*
	Striped snakehead	Nga yant kar	*Channa striata*
	Tilapia	Tilapia	*Oreochromis niloticus*
Large fish	Rohu	Ng myit chin	*Labeo rohita*

4.2.4 Fish and the economics of nutrition

In 2001, the average rural household spent most of their food money on rice (17.45% of food spending) followed by fish and fish products (12%) (Khin Maung Soe, 2008). A more recent study reported food expenditures to be highest on rice (204 Myanmar Kyats [MMK] per day), meat (MMK 100/day), vegetables (MMK 92/day), and fish and other seafood (MMK 82/day) (LIFT, 2013). These food expenditures could be attributed to small fish being generally more accessible and more evenly distributed among household members than other, more expensive protein sources (i.e., animal source foods or large fish) (Kawarazuka and Béné, 2011). According to 2008 statistics, fish and fisheries products were estimated to account for 10% of monthly expenditures for an average household and 14.27% of the monthly food and beverage spending (MMRD, 2010).

Consumption of traditional foods is hampered by price increases in fisheries. In 2010, MMRD reported that 59% of fishers were buying fish for their own consumption. For example, mud crab is now a highly desirable and valuable export and, therefore, no longer able to have a significant place in the traditional diet of coastal communities (Marius, 2013).

4.3 The Gender Dimension in Fisheries

In 2014, female participation in the labour market was 75% compared to 82% for men (UNDP, 2015). Women usually work longer hours and have less leisure time than men. LIFT (2013) found female-headed households to have lower average incomes than male-headed households. Women are generally relegated to the lower ranks of workers in both the formal and informal sectors.

Due to child bearing, lactation, and social norms, women are among those most affected by food insecurity. When they do not have sufficient food for the whole family, women tend to reduce the quantity and quality of the food they eat. Some women also beg for food from neighbours and relatives, if required, which undermines their social status and self-esteem (LIFT, 2012a).

While fishing and aquaculture are male-dominated activities, women also play significant roles in fisheries. A number of small-scale fishers around Inle Lake, for example, are women. Around the Gulf of Mottama, Venkatesh (2015) found "plenty of evidence […] showing women taking part actively in fishing, especially in the inland water bodies. Depending on the circumstances, the women may fish along with their husbands, with other women, or on their own; they may go fishing in a boat or by wading in the shallow waters." FAO-NACA (2003) also found that many small-scale aquaculture ponds and hatcheries were either managed by women or that women "were engaged in routine management operations, such as feed preparation and/or feeding." Beyond catching fish, women play a dominant role in marketing fish (FAO-NACA, 2003; Friedrich-Ebert-Stiftung Foundation, 2009), and in processing (Johnstone et al., 2012; WorldFish at el., 2014; Schmidt and Khin Maung Soe, 2015).

Despite their integration in fisheries, women's contribution is often overlooked and undocumented (Siason et al., 2002). Gender-disaggregated data on fisheries in Myanmar are very scant, and women's rights to participate in sectoral decision making are often ignored. In Myanmar, the possible development of a network of women in fisheries appears to be a promising opportunity.

5 CHALLENGES AND OPPORTUNITIES IN AYEYARWADY FISHERIES

The sections below reflect not only the issues and opportunities identified in the above sections, but also the analyses and conclusions of several reviews in the sector (notably FAO-NACA, 2003; Johnstone et al., 2012 and 2013; MyFish, 2013 a and b; BOBLME, 2014 or MFP, 2016).

5.1 Main Challenges

5.1.1 *Lack of institutional capacity*

UNDP (2004) noted that DoF is "grossly under-funded, and ill equipped for its crucial tasks." The inadequate level of funding allocated to DoF means that the agency cannot manage the sector to either reach its full productive potential or conserve the resource base in the long term. Key symptoms of this lack of resources are a limited technical ability to implement fisheries projects and a lack of research that might validate the effectiveness of efforts to improve management approaches. Two manifestations of this low capacity are the lack of reliable data in the sector and lack of monitoring, compliance and enforcement capability.

5.1.2 *Lack of data for monitoring*

SEAFDEC (2012) explains that collection of freshwater capture fisheries' basic and routine data is by nature very complicated. The lack of accurate reporting from the inland fisheries sector in Myanmar means that the sector is subsequently accorded a low priority by planners and policy makers in relation to other development sectors. The issue is circular – underfunding leads to poor data collection that, in turn, leads back to ongoing underfunding.

The tradition of using centralized targets with the aim of maintaining or increasing government revenues can compromise data quality and create conditions for misreporting (Johnstone et al., 2013). An example of a data hole that needs filling is the quantity of fish needed to meet domestic demand - such missing data cannot currently inform the policy of exporting only after domestic demand is met.

To address the monitoring issues, BOBLME (2014) recommends the following:

- Data collection and statistics are de-linked from the "target planning process".
- The capacity of DoF in fisheries statistics, data collection, and analyses is increased at all levels (headquarters, region, districts, and townships), particularly with Ecosystem Approach to Fisheries Management training, sample-based fisheries data collection and statistics, and fisheries data analyses.
- The current paper-based system for data collection is replaced with a digital system.
- A standardized and sample-based data collection system for fisheries and aquaculture is put in place, with guidelines, appropriate data collection forms, and transparent procedures.
- Published data are revised, if possible, to provide more accurate insights about the real trends in catches since the 1994 to 1995 season.
- A pilot project is implemented in one or two divisions.

5.1.3 *Lack of monitoring and enforcement*

Noncompliance with regulations is widespread. Continued use of illegal gear, mesh sizes, and fishing techniques as well as fishing in restricted areas and reserves are common activities (Tsamenyi, 2011). The lack of monitoring and enforcement of regulations designed to ensure the longevity of fisheries resources poses an obvious problem for the sustainable management of the sector.

Preliminary recommendations to improve compliance and enforcement (Tsamenyi, 2011) include the following:

- Establish compliance and enforcement within the legal system of dedicated provisions for fisheries monitoring.

- Update fines to a level that reflects the severity of the impact of the infringement on resources, supports voluntary compliance, and acts as a deterrent.
- Develop some form of regulation for the 16 types of gear presently not requiring licensing by DoF.

5.1.4 The threat of dam development

One striking feature of the present review is the absence of information on the possible impact of hydropower development on a fishery characterized, like in the Mekong system, by huge yields and large-scale fish migrations. In the Mekong, extensive studies[2] all conclude that mainstream hydropower developments will have a major negative impact on fisheries resources. Two main mechanism are involved: 1) river fragmentation and subsequent disruption of fish migrations (particularly loss of access to breeding sites), and 2) significant loss of nutrients due to sediment retention by dams, resulting in an overall loss of water productivity (Baran et al., 2015). The scale of hydropower development plans (cf. the on-going Strategic Environmental Assessment of the Hydropower Sector in Myanmar) calls for an urgent and detailed analysis of the possible impact of these development plans on fishery resources in the country.

5.2 Main Opportunities

5.2.1 Opportunities for interagency coordination

Although interagency cooperation may seem too obvious a suggestion, presumably, if it were easy, it would already be happening.

DoF has been working with external agencies to improve its services. According to its 2010 report, it has been working with FAO, NACA, SEAFDEC, the Japan International Cooperation Agency (JICA), and other regional and international fisheries-related organizations. This kind of networking is extremely valuable and must continue.

Even without a national policy mandate, there is a great deal that can be achieved through communication, agreements, and cooperation between government line agencies. Some pioneers illustrate such interagency coordination efforts. For example, the National Water Resources Committee bringing together representatives from 23 government agencies was set up in July 2013 with the task of integrating their work. In the Sagaing Region, the Ministry of Agriculture and Irrigation and the Ministry of Livestock, Fishery, and Rural Development have been integrated into one single regional ministry since April 2011. According to a Sagaing regional fisheries officer, "under the previous situation, nobody could start pond fish culture without the recommendation from the Ministry of Agriculture and Irrigation in Nay Pyi Taw. It used to take years to get this recommendation and permission from different departments. Nowadays, applications can be processed smoothly through the Regional Minister" (MYFish, 2013b).

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[2] BDP2 Fisheries Impact Assessment presented in July 2010; the International Centre for Environmental Management's (ICEM's) Strategic Environmental Assessment of mainstream hydropower (2010); Ziv et al.'s study of fish biodiversity, food security, and hydropower in the Mekong (2012); the Inland Fisheries Research and Development Institute's (IFReDI's) 2013 study of food and nutrition security vulnerability to mainstream hydropower dam development in Cambodia; and DHI's study on the impacts of mainstream hydropower on the Mekong River in 2015.

5.2.2 *Potential benefits of co-management*

Co-management is also known as "participatory management," "community-based management," or "collaborative management". Under this concept, fisheries resources are a common property resource to which a group of people have common user rights. Common property resources are not open-access but are subject to rules and conventions of local communities" (UNDP, 2004).

In the context of inland fisheries, co-management provides a mechanism to help complement the efforts of government agencies to manage the sector. Such community-based management could help alleviate rural poverty. UNDP (2004) explains that many villagers are unable to extract fish from the rivers on which their land borders, because a limited number of leaseholders have exclusive rights to the resource and do not provide the villagers with access.

Cooperative management systems have a number of benefits, including the following:

- They can help improve data collection and monitoring, with fishing communities themselves collecting data and sending it for inclusion in national databases. The system is not likely to be perfect but almost certainly better than now.
- They could help with enforcement of fisheries regulations, with communities having greater incentive to take responsibility and ownership of guarding their resources against overexploitation. This could provide substantial assistance to DoF, which faces a scarcity of staff (MYFish, 2013b).
- They would facilitate greater levels of communication and understanding between DoF and fisher communities.

Tsamenyi (2011) suggests a step-by-step approach to introducing a fisheries co-management system in Myanmar, piloting the approach on a small scale first. Success in the forestry sector in introducing co-management arrangements can serve as a useful model for introducing similar arrangements into the fisheries sector. UNDP (2004) also suggests a range of steps to help introduce the model in such a manner that it will have firm, locally relevant, and community-supported foundations.

In the implementation of community fisheries, Myanmar should also capitalize on experience in neighboring countries, in particular in Cambodia.

5.2.3 *The opportunity presented by reservoir fisheries*

Myanmar has a large holding of reservoirs and lakes. FAO has observed that other countries have actively established rich and successful fisheries in reservoirs with little environmental impact (FAO-NACA, 2003).

Reservoir fishing was encouraged in Myanmar historically. However, the practice has been banned since 1995 by the Department of Irrigation, based on perceptions that fishing in reservoirs is environmentally unsound and that it would deprive surrounding farmers of spillover fish (FAO-NACA, 2003). Since the ban, few people harvest fish in reservoirs, even though small-scale subsistence fishing tends to continue (MYFish, 2013b). As a result, exploitation has been low, unmonitored, and these landings are presently not included in national catch totals (UNDP, 2004). In the meantime, DoF has continued stocking the reservoirs with Indian and Chinese major carp "for conservation purposes" (UNDP, 2004). For instance, in 2012–2013, DoF released 400,000 seeds into the Tha Phan Seik Reservoir in the Kyun Hla Township of the Sagaing Region (MYFish, 2013b).

A softening of the policy toward the reservoir fishing ban seems to be taking shape, at least at a regional level. For example, the Sagaing Regional Government agreed with the principle of allowing neighboring communities to fish in reservoirs of less than 5,000 acres (200 hectares [ha]) that are under local government control (bigger reservoirs are under Ministry management; MYFish, 2013b).

Experience in other Asian countries demonstrates that there should not be any conflict between the creation of reservoirs for irrigation purposes and the utilization of those bodies of water for fish production. Other countries in the region have been extracting large quantities of fish from their reservoir systems each year (UNDP, 2004).

FAO-NACA (2003) suggested that reservoir fishing be reintroduced slowly, initially on a small scale, in conjunction with the irrigation authorities, while including research to assess suitable strategies, cost-effectiveness, and sustainability. UNDP supports this approach, stating that "although the key step involved is one of reversing the existing policy position, it is clear that the re-introduction of reservoir fisheries should be accompanied by a monitoring and supervision program that determines the economic value of the catch, ensures appropriate licensing income for the Government, and ensures a minimal environmental impact. A unit could be created within the Department of Fisheries specifically to manage these responsibilities" (UNDP, 2004).

In 2003, it was estimated that reservoir fishing could provide employment to at least 20,000 to 30,000 people in Myanmar (FAO-NACA, 2003). That figure is likely to be higher today. Even if a very low production level (such as 50 kg/ha) was assumed, the reservoir fishery resources of Myanmar could presently be yielding about 90,000 metric tons of fish per year (UNDP, 2004). Such a yield could have a significant impact on national food supplies and, particularly, on food security for resource-poor inland families.

5.3 Conclusions and Recommendations

We propose below a table (Table 7) summarising the main findings of the study, and the level of confidence about each finding (High / Medium), based on a combination of studies available, convergence between studies, and evidence from field-based surveys.

Table 7– Main findings and estimated confidence level based on evidence available

No.	Main finding	Confidence level
1	Very high capture fisheries production by global standards	High
2	Essential contribution of fisheries to rural food and nutrition security	High
3	Important contribution of fisheries to rural livelihoods, in particular in the delta	High
4	High fish biodiversity, and evidence of healthy fish resources in several river segments	Medium
5	Important contribution of inland capture fisheries to total fish production	High
6	High ecological role of the tip of the delta for migratory species, calling for protection	Medium
7	Importance of migratory species in the catch of inland fish	Medium
8	Clear signs of fisheries production decline in the delta	High
9	Sustainability warning signals in inland fisheries	Medium
10	Fish resources are threatened by destructive practices (electrofishing, poisoning, habitat destruction)	High
11	Dam development is a potentially high but undocumented threat to inland and coastal fisheries	Medium
12	People call for a better enforcement of the existing legislation	High
13	Need to set up a fisheries monitoring system based on field sampling	High

Table 8 summarizes the main recommendations of the study, and the level of priority for each recommendation (Urgent / High / Medium), based on a combination of feasibility and relevance to fisheries sustainability.

Table 8 – Main recommendations and priority level

No.	Recommendation	Priority
1	Take action against electrofishing and poisoning	Urgent
2	De-link data collection and statistics from the "target planning process"	Urgent
3	Initiate an assessment of the impact of hydropower development on fisheries resources and food security	Urgent
4	Increase the capacity of DoF in fisheries statistics at all levels and move towards a computer-based system	High
5	Put in place a standardized and sample-based data collection system for fisheries and aquaculture, and implement a pilot monitoring project in at least one or two divisions.	High
6	Progressively allow the conversion of agricultural land into fish ponds	High
7	Improve law enforcement, including through i) increased cooperation between the authorities and the resource users, and ii) between different government departments.	High
8	Progressively develop inland fisheries co-management initiatives	Medium
9	Allow some form of fishing in reservoirs	Medium
10	Impose restrictions on the use of pesticides and more generally on the release of pollutants	Medium
11	Undertake reclamation activities, in particular replanting and conservation of mangrove forest.	Medium
12	Study the conditions for optimized stocking	Medium
13	Improve coordination between line agencies and parties (in particular between fishers and the DoF and between fishers and farmers).	Medium

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ANNEX I – DATA CORRESPONDING TO FIGURES OF THE REPORT

Trends in marine capture fisheries, freshwater capture fisheries, and aquaculture between 2000 and the latest data available. Source: FAO FIGIS data, September 2017

	2000	2001	2002	2003	2004	2005	2006	2007
Freshwater capture fish	196,060	238,210	254,880	290,140	454,260	503,540	631,120	718,190
Marine capture fish	873,240	926,070	1,006,160	1,030,720	1,109,640	1,206,330	1,162,100	1,159,400
Aquaculture fish	93,948	115,793	183,550	232,789	370,310	435,580	524,387	554,857
Total (September 2017)	1,163,248	1,280,073	1,444,590	1,553,649	1,934,210	2,145,450	2,317,607	2,432,447

	2008	2009	2010	2011	2012	2013	2014	2015
Freshwater capture fish	739,140	757,810	785,550	798,130	830,730	838,090	852,530	863,450
Marine capture fish	1,138,292	1,105,394	1,145,826	1,148,000	1,102,600	1,052,876	1,089,200	1062,000
Aquaculture fish	618,897	697,310	772,862	758,442	824,457	871,353	903,751	942,251
Total (September 2017)	2,496,329	2,560,514	2,704,238	2,704,572	2,757,787	2,762,319	2,845,481	2,867,701

Reassessment in 2017 of catch statistics of the 2003-2014 period. Source: FAO FIGIS data in November 2016 and September 2017

Comparison	2003	2004	2005	2006	2007
Freshwater capture, 2016 estimate	290,140	454,260	503,540	631,120	717,640
Freshwater capture 2017 estimate	290,140	454,260	503,540	631,120	718,190
Marine capture, 2016 estimate	1,030,720	1,109,640	1,206,330	1,345,370	1,485,740
Marine capture, 2017 estimate	1,030,720	1,109,640	1,206,330	1,162,100	1,159,400
Aquaculture fish, 2016 estimate	232,789	370,310	435,580	524,387	554,857
Aquaculture fish, 2017 estimate	232,789	370,310	435,580	524,387	554,857

Comparison	2008	2009	2010	2011	2012	2013	2014
Freshwater capture, 2016 estimate	814,740	899,430	1,002,430	1,163,159	1,246,460	1,302,970	1,381,030
Freshwater capture 2017 estimate	739,140	757,810	785,550	798,130	830,730	838,090	852530
Marine capture, 2016 estimate	1,643,600	1,827,800	2,016,600	2,123,400	2,282,600	2,430,526	2,644,400
Marine capture, 2017 estimate	1,138,292	1,105,394	1,145,826	1,148,000	1,102,600	1,052,876	1,089,200
Aquaculture fish, 2016 estimate	618,897	697,311	772,862	758,442	824,457	871,353	903,751
Aquaculture fish, 2017 estimate	618,897	697,310	772,862	758,442	824,457	871,353	903,751

Table 9: DoF fisheries statistics. Source: DoF 2016 and previous years

Year / Metric tons	Aquaculture	Leasable	Open	Marine	Total
2003-2004	400,360	122,280	331,980	1,132,340	1,986,960
2004-2005	485,220	136,790	366,750	1,228,710	2,217,470
2005-2006	574,990	152,690	478,430	1,375,670	2,581,780
2006-2007	616,350	170,100	548,090	1,525,320	2,859,860
2007-2008	687,670	191,050	625,440	1,689,760	3,193,920
2008-2009	775,250	209,720	689,710	1,867,510	3,542,190
2009-2010	858,760	237,460	764,970	2,060,780	3,921,970
2010-2011	830,480	250,040	913,130	2,169,820	4,163,470
2011-2012	896,960	282,640	963,820	2,332,790	4,476,210
2012-2013	929,380	290,000	1,012,970	2,483,870	4,716,220
2013-2014	964,260	304,440	1,076,590	2,702,240	5,047,530
2014-2015	999,630	315,360	1,147,760	2,854,200	5,316,950
2015-2016	1,014,420	338,690	1,241,980	2,996,740	5,591,830

ANNEX II – MIGRATIONS AND BREEDING IN THE AYEYARWADY SYSTEM

Species by zone and habitat type

<table>
<tr><th>Zone</th><th>Habitat Type</th><th>Habitat Name</th><th>Species Observed</th></tr>
<tr><td rowspan="2">Central Dry Zone</td><td rowspan="2">River</td><td>Ayeyawady River</td><td>Cirrhinus cirrhosus/mrigala; Hemibagrus microphthalmus; Labeo calbasu; Sperata sp.; Tenualosa ilisha; Wallago attu</td></tr>
<tr><td>Chindwin River</td><td>Catla catla; Cirrhinus cirrhosus/mrigala; Labeo calbasu; Tenualosa ilisha; Wallago attu</td></tr>
<tr><td rowspan="11">Delta</td><td rowspan="2">Flood Plain</td><td>Bogale River</td><td>Lates calcarifer</td></tr>
<tr><td>Toe River</td><td>Lates calcarifer</td></tr>
<tr><td rowspan="2">Paddy Field</td><td>Pyapon Township</td><td>Lates calcarifer</td></tr>
<tr><td>Toe River</td><td>Lates calcarifer</td></tr>
<tr><td rowspan="6">River</td><td>Ayeyawady River</td><td>Bagarius bagarius; Catla catla; Cirrhinus cirrhosus/mrigala; Gudusia variegata; Hemibagrus microphthalmus; Labeo calbasu; Pangasius sp.; Pangasius pangasius; Rita sp.; Silonia silondia; Sperata sp.; Tenualosa ilisha; Wallago attu</td></tr>
<tr><td>Nga Wann River</td><td>Catla catla; Cirrhinus cirrhosus/mrigala; Hemibagrus microphthalmus; Labeo calbasu; Pangasius pangasius; Rita sp.; Silonia silondia; Sperata sp.; Tenualosa ilisha; Wallago attu</td></tr>
<tr><td>Toe River</td><td>Catla catla; Cirrhinus cirrhosus/mrigala; Labeo calbasu; Pangasius sp.; Pangasius pangasius; Silonia silondia; Tenualosa ilisha; Wallago attu</td></tr>
<tr><td>Yangon River</td><td>Pangasius sp.; Tenualosa ilisha</td></tr>
<tr><td>Yarzudaing River</td><td>Lates calcarifer; Tenualosa ilisha; Wallago attu</td></tr>
<tr><td>Ywe River</td><td>Tenualosa ilisha</td></tr>
<tr><td>River Bank</td><td>Pyapon River</td><td>Catla catla; Pangasius pangasius</td></tr>
</table>

Overview of migration and breeding in the Ayeyarwady system

Species	Migration and/or Distribution	Breeding Sites
Bagarius sp.	No information	Breeding sites along Ayeyarwady River in Pyay Township. Biggest breeding site in Pyay Township. Breeding season: March to April
Gibelion catla (formerly *Catla catla*)	Upstream migration of big fishes (approximately 20 inches) in the delta (September to November) and in the Central Dry Zone (February to April and September to December). Downstream migration of small fishes (10 inches). Highest yield in Twantay (135 kg/day/fisher in September); lowest in Mawgyun (< 5 kg/day/fisher in November).	Breeding sites along 4 rivers (Chindwin, Ayeyarwady, Pathein, and Toe) in Kalewa, Kyangin, Myanaung, Monyo, Ingapu, Hinthada, Zalun, Danubyu, Yandoon, Twantay, Ngathaingchaung, and Wakema Townships. Biggest breeding site in Ingapu along Pathein River. Breeding season: May to August
Cirrhinus cirrhosis	Upstream migration of big and small fishes in the delta and the Central Dry Zone (January to May and September to December). Downstream migration of 20 inch individuals from April to May. Highest yield in Myinmu (45 kg/day/fisher in November); lowest in Maubin and Dedaye (5 kg/day/fisher).	Breeding sites along 3 rivers (Ayeyarwady, Pathein, and Toe) in Ingapu, Myanaung, Danubyu, Zalun, Yandoon, Twantay, and Ngathaingchaung Townships. Biggest breeding site in the floodplains along Pathein river in Ingapu. Breeding season: May to June.
Cirrhinus mrigala	No information	Breeding sites along 2 rivers (Ayeyarwady River and Pathein River) in Hinthada, Ingapu, Kalewa, Katha, and Monyo Townships. Biggest breeding site in Ingapu along Pathein River. Breeding season: March to July
Gudusia variegata	No information	Breeding site along Ayeyarwady River in Hinthada Township. Biggest breeding site in Hinthada along Ayeyarwady River. Breeding season: March to April
Hemibagrus microphthalmus	No information	Breeding sites along 2 rivers (Ayeyarwady River and Pathein River) in Ingapu, Myanaung, and Myinmu Townships. Biggest breeding site in Ingapu along Pathein River. Breeding season: June to July

Species	Migration and/or Distribution	Breeding Sites
Hilsa kelee	Upstream migration of small and big fishes in the delta (January to June and September to December) and in the Central Dry Zone (October to November). Highest yield in Wakema (8 kg/day/fisher); lowest in Kyangin (5 kg/day/fisher).	No information
Ilisha megaloptera	Upstream migration in the delta (April - August). Highest yield in Bogale (30 kg/day/fisher in August); lowest in Mawgyun (< 3 kg/day/fisher).	No information
Labeo calbasu	Upstream migration of juveniles and big fishes in the delta (January, May, and October) and in the Central Dry Zone (April to June and August to November). Highest yield in Ingapu (25 kg/day/fisher in September); lowest in Kyangin (< 1 kg/day/fisher between April and June).	Breeding sites along 4 rivers (Ayeyarwady River, Chindwin River, Pathein River, and Toe River) in Katha, Kalewa, Pakokku, Ingapu, Myanaung, Hinthada, Maubin, and Yandoon Townships. Biggest breeding site in the floodplains along Pathein River in Ingapu. Breeding season: June to February
Lates calcarifer	Upstream migration of small and big fishes in September to January. Highest yield in Wakema (115 kg/day/fisher in November); lowest in Pyapon (1 kg/day/fisher in November).	Breeding sites along 8 rivers (Toe River, Donyan River, Pyapon River, Myngagon River, Ayeyarwady River, Bogale River, Kyondon River, and Salween River) in Bogale, Dedaye, Kyaik Hto, Mawgyun, Pyapon, Thanatpin, and Waw Townships. Biggest breeding site in Dedaye along the Toe River. Breeding season: May to June
Pangasius sp.	Upstream migration of adult fishes in the delta (January to May and September to November) and in the Central Dry Zone (September to December and February to April). Highest yield in Kyangin (200 kg/day/fisher in October); lowest in Pakokku (2 kg/day/fisher in April).	Breeding sites along 3 rivers (Toe River, Ayeyarwady River, and Yangon River) in Kyangin, Kyauktan, Twantay, and Yandoon Townships. Biggest breeding site in the floodplains of Twantay along the Toe River Breeding season: May to August

Species	Migration and/or Distribution	Breeding Sites
Pangasius pangasius	Upstream migration of 15 to 20 inch fish in the delta (January to April and October to December) and in the Central Dry Zone (February to November, except June). Highest yield in Twantay (120 kg/day/fisher in November); lowest in Myingyan (3 kg/day/fisher).	Breeding sites along 4 rivers (Pyapon River, Ayeyarwady River, Yangon River, Salween River) in Hinthada, Htantabin, Myanaung, Kyaik Hto, Twantay, and Pyapon Townships Biggest breeding site in mainstream of Pyapon River in Pyapon. Breeding season: December to June
Pangasianodon gigas	No information	Breeding site in the junction of Toe River and Twantay Canal in Twantay Township. Biggest breeding site in Twantay Township. Breeding season: no information
Rita sp.	Upstream migration of fish in the delta (March to December) and in the Central Dry Zone (January to April and October to December). Highest yield in Kyangin (300 kg/day/fisher in October); lowest in Mawgyun (< 1 kg/day/fisher).	Breeding sites along 2 rivers (Ayeyarwady River and Pathein River) in Pyay, Myanaung, Zalun, and Thabaung Townships. Biggest breeding site along Ayeyarwady River in Pyay. Breeding season: March and October
Silonia silondia	Upstream migration of 15 to 20 inch fish in the delta (January - March and between September - December) and in the Central Dry Zone (September to October). Highest yield in Ingapu (15 kg/day/fisher in September); lowest in Patheingyi (1 kg/day/fisher).	Breeding sites along Ayeyarwady River in Hinthada, Yandoon, and Maubin Townships. Biggest breeding site in Hinthada along Ayeyarwady River. Breeding season: May to June.
Sperata sp.	No information	Breeding sites along Ayeyarwady River in Hinthada and Zalun Townships. Biggest breeding site in Hinthada along Ayeyarwady River. Breeding season: April to May
Wallago attu	Upstream migration of young and adult fish in the delta (January to March and between September to December) and in the Central Dry Zone (January to April and October to December). Highest yield in Myinmu (120 kg/day/fisher in November); lowest in Pakokku (2 kg/day/fisher in March).	Breeding sites along 5 rivers (Ayeyarwady River, Myngagon River, Pathein River, Toe River, and Salween River) in Katha, Kalewa, Myinmu, Pakokku, Kyaik Hto, Kyangin, Myanaung, Ingapu, Thabaung, Hinthada, Maubin, Twantay, Mawgyun, Zalun, Yandoon, and Waw Townships. Biggest breeding site in Myngagon and the lower part of Ayeyarwady in Mawgyun. Breeding season: May to July