SECTOR ENVIRONMENTAL GUIDELINES

WILD-CAUGHT FISHERIES AND AQUACULTURE

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Cover Photo: Landing of sardinella in Ghana. 2015. Photo Credit: URI Coastal Resources Center

ABOUT THIS DOCUMENT AND THE *SECTOR ENVIRONMENTAL GUIDELINES*

This document presents two sectors – wild-caught fisheries and aquaculture - within the *Sector Environmental Guidelines* prepared for USAID under the Agency's Global Environmental Management Support Project (GEMS). All sector guidelines are accessible at www.usaidgems.org/bestPractice.htm.

Purpose. The purpose of this document and the *Sector Environmental Guidelines* overall is to support environmentally sound design and management of common USAID sectoral development activities by providing concise, plain-language information regarding:

- the typical, potential adverse impacts of activities in these sectors;
- how to prevent or otherwise mitigate these impacts, both in the form of general activity design guidance and specific design, construction, and operating measures;
- how to minimize vulnerability of activities to climate change; and
- more detailed resources for further exploration of these issues.

Environmental Compliance Applications. USAID's mandatory life-of-project environmental procedures require that the potential adverse impacts of USAID-funded and managed activities be assessed prior to implementation via the Environmental Impact Assessment (EIA) process defined by 22 CFR 216 (Reg. 216).

They also require that the environmental management/mitigation measures ("conditions") identified by this process be written into award documents, implemented over life of project, and monitored for compliance and sufficiency.

The procedures are USAID's principal mechanism to assure environmentally sound design and management of USAID-funded activities—and thus to protect environmental resources, biodiversity, ecosystems, ecosystem services, and the health and livelihoods of beneficiaries and other groups. They strengthen and sustain development outcomes and help safeguard the good name and reputation of USAID.

The *Sector Environmental Guidelines* directly support environmental compliance by providing information essential to assessing the potential impacts of activities, and to the identification and detailed design of appropriate mitigation and monitoring measures.

However, the Sector Environmental Guidelines *are **not** specific to USAID's environmental procedures. They are generally written, and are intended to support environmentally sound design and management of these activities by all actors, regardless of the specific environmental requirements, regulations, or processes that apply, if any.*

Development Process & Limitations. In developing this document, regional-specific content in these predecessor guidelines has been retained. Statistics have been updated, and references verified and some new references added. However, this document is not the result of a comprehensive technical update.

Further, the Sector Environmental Guidelines are not a substitute for detailed sources of technical information or design manuals. Users are expected to refer to the accompanying list of references for additional information.

Comments and corrections. Each sector of these guidelines is a work in progress. Comments, corrections, and suggested additions are welcome. Email: gems@cadmusgroup.com.

Advisory. *The* Sector Environmental Guidelines *are advisory only. They are not official USAID regulatory guidance or policy. Following thepractices and approaches outlined in the* Sector Environmental Guidelines *does not necessarily assure compliance with USAID environmental procedures or host country environmental requirements.*

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USING THESE GUIDELINES

The *Sector Environmental Guidelines* are intended for use by USAID and its partners. Following are brief recommendations for each of these user groups:

Agency technical or program office staff who are designing or providing technical expertise to colleagues and country missions on fisheries and aquaculture programs and projects may find Sections II – VI most useful for policy context, overview of the sector, potential negative environmental impacts, climate change considerations, and environmental guidance on project design.

Country and regional mission program staff (Contracting and Agreement Officer's Representatives, Activity Managers, and Environmental Compliance Officers) would also find sections II – VI useful for program and project design, including key elements to address in accompanying Initial Environmental Examinations. Section VII will be most useful for oversight of implementing partners' in planning, monitoring, and reporting on environmental mitigation measures during project implementation.

Implementing partners will benefit from each of the sections of this guide depending on the needs of the project/activity cycle for design, implementation, monitoring, reporting, or evaluation. The Resources and References section and Annex of on-going USAID fisheries and aquaculture projects may also be most useful for this group of users.

Key Terms

Wild-caught fisheries: In this guide, the term "fisheries" refers to wild-caught fisheries (also called capture fisheries). The term covers marine, brackish, and freshwater; commercial and subsistence; and industrial- and small-scale fisheries.

Aquaculture: "The farming of aquatic organisms, including fish, mollusks, crustaceans, and aquatic plants. Farming implies some form of intervention in the rearing process to enhance production, such as regular stocking, feeding, protection from predators, etc. Farming also implies individual or corporate ownership of the stock being cultivated" (FAO, 1988).

Small-scale fisheries: Also referred to as artisanal fisheries. Characteristics differ among countries, but the term generally means, "traditional fisheries involving fishing households (as opposed to commercial companies), using a relatively small amount of capital and energy, relatively small fishing vessels (if any), making short fishing trips, close to shore, mainly for local consumption" (FAO, 2014). "Women are significant participants in the sector, particularly in post-harvest and processing activities. It is estimated that about 90 percent of all people directly dependent on capture fisheries work in the small-scale fisheries sector. As such, small-scale fisheries serve as an economic and social engine, providing food and nutrition security, employment and other multiplier effects to local economies while underpinning the livelihoods of riparian communities" (FAO, SSF Guidelines, 2015).

Commercial fishing: Catching wild fish and other seafood for commercial profit. The term includes the whole process of catching and marketing fish and shellfish for sale. It refers to fisheries resources, fishers, and related businesses (NOAA, 2006). Commercial fishing is done by both large- and small-scale fisheries.

Industrial fisheries: Commercial fishing on a large scale. "It more generally refers to the high level of technology, investment, and impact it brings to a fishery. With few exceptions, these fisheries use big boats that are worth many millions of dollars and they are equipped with technology capable of efficient, giant catches." (World Fisheries Trust, 2008). They are often equipped with on-board facilities for freezing and processing seafood at sea.

Fishing capacity: "The ability of a fleet (and all related inputs) to catch fish. Indicators are usually used to gauge capacity levels. The simplest way of doing so is to count the number of boats in a fishing fleet. But more accurate assessments also take into account other variables: the kinds of boats that make up the fleet, including their size; the horsepower of their engines; how many days a year they can operate; and what kind of gear they use" (FAO, 2004). "When existing capacity is greater than what is necessary to sustainably harvest a given fish stock, the result is **overcapacity**" (FAO, 1999).

Fishing effort: This term is a measure of the amount of fishing in an area over a given time period. A common surrogate to estimate fishing effort is "the amount of fishing gear of a specific type used on the fishing grounds over a given unit of time" (NOAA, 2006).

THE POLICY CONTEXT AND USAID PROGRAMMING IN WILD-CAUGHT FISHERIES AND AQUACULTURE

USAID investments in wild-caught fisheries (hereafter referred to as fisheries) and aquaculture (or "farmed" fish) are made in the context of international, national, and agency guidelines, agreements, and policies. These policies represent the governance framework within which USAID projects in the fisheries and aquaculture sector are designed, implemented, and evaluated for responsible environmental stewardship. Key recent policies are referenced below. Additional resources are found in the Resources and References section.

INTERNATIONAL GUIDELINES AND AGREEMENTS

United Nations 2030 Agenda for Sustainable Development, Sustainable Development Goals (2015).

- SDG 2 - Zero hunger: End hunger, achieve food security and improved nutrition, and promote sustainable agriculture.
- SDG 14 – Life below water: Conserve and sustainably use the oceans, seas, and marine resources for sustainable development.
- SDG 15 - Life on Land: Protect, restore, and promote sustainable use of terrestrial ecosystems, sustainably manage forests, combat desertification, and halt and reverse land degradation and halt biodiversity loss.

FAO Code of Conduct for Responsible Fisheries (1995). Together with the fishing provisions of the UN Convention on the Law of the Sea, the FAO Code is the most widely recognized and implemented international fisheries instrument. Its objective is to promote long-term, sustainable fisheries and aquaculture. It prescribes principles and standards for the conservation and management of all fisheries. It also addresses the capture, processing, and trade in fish and fishery products, fishing operations, aquaculture, fisheries research, and the integration of fisheries into coastal area management. The Code is voluntary, but FAO member countries have committed to implement it.

FAO Voluntary Guidelines for Securing Sustainable Small-Scale Fisheries in the Context of Food Security and Poverty Eradication (The SSF Guidelines) (2015). The Small-Scale Fisheries (SSF) Guidelines are the first internationally agreed instrument dedicated to the small-scale fisheries sector and they recognize the significant participation of women in the sector. The SSF Guidelines complement the FAO Code of Conduct for Responsible Fisheries.

Port States Measures Agreement (PSMA) to Prevent, Deter, and Eliminate Illegal, Unreported, and Unregulated (IUU) fishing (entered into force in June 2016 after ratification by a minimum of 25 countries, including the U.S.). "The PSMA is the first internationally binding treaty aimed at combating IUU fishing. It requires countries to exert greater controls on foreign-flagged vessels seeking to enter and use their ports. Operators must submit a request to authorities in these states when they want to land or transship catch. The authorities may refuse entry to vessels known to have engaged in illegal fishing, or immediately inspect them and block their access to port services."[1] FAO highlights that, "while there are options for combating IUU fishing at sea, they are often expensive and—especially for developing countries—can be difficult to implement, given the large ocean spaces that need to be monitored and the costs of the required technology."[2]

U.S. GOVERNING POLICY

Foreign Assistance Act (FAA) of 1961 as amended, Section 117 – Environment and Natural Resources. This section requires USAID to utilize an Environmental Impact Assessment process to evaluate the potential impact of USAID's activities on the environment prior to implementation, and to "fully take into account" environmental sustainability in designing and carrying out its development programs. It states, "Special efforts shall be made to maintain, and where possible, restore the land, vegetation, water, wildlife, and other resources upon which depend economic growth and human well-being especially that of the poor."

FAA, Section 118 – Tropical Forests. This section establishes programming mandates related to tropical forests, including mangroves, which are relevant to aquaculture and fisheries. This policy requires that: "Each country development strategy statement or other country plan prepared by the Agency for International Development shall include an analysis of (1) the actions necessary in that country to achieve conservation and sustainable management of tropical forests, and (2) the extent to which the actions proposed for support by the Agency meet the needs thus identified."

FAA Section 119 – Endangered Species. This section establishes programming mandates related to biodiversity and requires that: "Each country development strategy statement or other country plan prepared by the Agency for International Development shall include an analysis of (1) the actions necessary in that country to conserve biological diversity, and (2) the extent to which the actions proposed for support by the Agency meet the needs thus identified."

USAID Biodiversity Policy (2015). "The USAID Biodiversity Policy builds upon the Agency's long history of conserving a global biological heritage for current and future generations and reflects a deep understanding of the role that healthy natural systems play in achieving the Agency's human-development goals. The Policy recognizes that biodiversity loss can be driven by unsustainable development, that there may be trade-offs that must be understood and managed between biodiversity conservation and development goals, and that biodiversity conservation itself can be a critical tool in the Agency's toolkit for achieving sustainable development."

USAID Biodiversity Code (2015). The Code, "defines four criteria required of programs which use funds designated for biodiversity. Each year, all biodiversity programs are reviewed for consistency with the Code. The four criteria are:

1. The program must have an explicit biodiversity objective; it is not enough to have biodiversity conservation result as a positive externality from another program;

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1. http://www.pewtrusts.org/~/media/assets/2017/11/eifp_port_state_measures_agreement_why_seafood_buyers_should_help.pdf
2. http://www.fao.org/news/story/en/item/417286/icode/

2. Activities must be identified based on an analysis of drivers and threats to biodiversity and a corresponding theory of change;
3. Site-based programs must have the intent to positively impact biodiversity in biologically significant areas; and,
4. The program must monitor indicators associated with a stated theory of change for biodiversity conservation results.

U.S. Government Global Food Security Strategy (2017-2021) supported by the Feed the Future Initiative. The Strategy's vision is "a world free from hunger, malnutrition, and extreme poverty, where thriving local economies generate increased income for all people; where people consume balanced and nutritious diets, and children grow up healthy and reach their full potential; and where resilient households and communities face fewer and less severe shocks, have less vulnerability to the shocks they do face, and are helping to accelerate inclusive, sustainable economic growth." It calls for a comprehensive approach that includes farmers, fishers, foresters, and pastoralists, paying special attention to women, the extreme poor, small-scale producers, youth, marginalized communities, and small and medium enterprises.

Presidential Initiative on Combating Illegal, Unreported, and Unregulated (IUU) Fishing and Seafood Fraud (2014). The initiative established a Presidential Task Force, co-chaired by the Departments of State and Commerce, which developed an Action Plan for Implementing 15 recommendations, including roles defined for USAID. The plan identifies actions that will strengthen enforcement; create and expand partnerships with state and local governments, industry, and non-governmental organizations; and create a risk-based traceability program to track seafood from harvest to entry into U.S. commerce. The *NOAA Seafood Import Monitoring Program (SIMP: enacted January 2017)* is one such program. The Task Force Action Plan also highlights ways in which the United States will work with our foreign partners to strengthen international governance, enhance cooperation, and build capacity to manage fisheries sustainably and combat illegal fishing and seafood fraud.

USAID STRATEGY AND PROGRAMMING IN WILD-CAUGHT FISHERIES AND AQUACULTURE

USAID's marine biodiversity and other fisheries activities aim to conserve biodiversity and increase human well-being through sustainable management of fisheries and conservation of coastal and marine habitats in national waters. Activities span more than 15 countries in Southeast Asia, Africa, Latin America, and the Caribbean and represent nearly $40 million per year in investments, including freshwater fisheries management in Malawi and the Democratic Republic of the Congo. Approaches focus on improving governance, promoting participatory decision-making, and enhancing natural productivity through ecosystem-based management, national level and community-based fisheries management, co-management, marine protected areas, and watershed management, as well as investing in improved seafood supply chain transparency and traceability with the goal of using these data to improve legality and sustainability.

Learn more about USAID's marine biodiversity programming through:

- The Interactive Inventory of Capacity Building Initiatives for Fisheries
- The USAID Biodiversity Conservation Gateway

USAID activities also include aquaculture or fish farming research in nine countries in Africa and Asia. USAID's aquaculture research activities aim to cultivate international multidisciplinary partnerships to advance novel solutions that support the goals of reducing global hunger, poverty, and undernutrition by developing comprehensive, sustainable, ecologically compatible, and socially viable aquaculture systems. Annex I provides a summary of ongoing examples of USAID fisheries projects and aquaculture research projects.

Learn more about USAID's aquaculture programming through:

- The Feed the Future Innovation Lab for Aquaculture and Fisheries.

Promoting good governance and improving fisheries and aquaculture management are priority themes for USAID investments in fisheries and aquaculture. Poor governance and weak management systems in fisheries and aquaculture are the leading causes of overfishing and significant environmental and social impacts from aquaculture. Improving the institutional and regulatory frameworks for fisheries management and aquaculture development contributes to the USAID goal of promoting transparent and participatory democracy. This includes strengthening the rule of law (e.g., fisheries enforcement and aquaculture regulation including land tenure, water rights, and environmental guidelines) and improving civil society engagement (enhanced participation through co-management approaches). Governance and management considerations are therefore woven throughout these *Sector Environmental Guidelines*.

The type of funding available for a project often factors into the potential for negative environmental or social impacts. The following sections highlight key funding sources and examples of the types of USAID fisheries and aquaculture projects funded by each. **Figure 1** below illustrates the influence of the source of USAID funding on project objectives. It also illustrates the potential negative environmental impacts to consider under each funding source and shows that climate risk management should be mainstreamed with equal importance regardless of funding source to enhance resilience of socio-economic and environmental systems.

BIODIVERSITY PROGRAMMING

In recent years, most USAID fisheries projects have been funded entirely or in some part with biodiversity funds. For example:

- The Philippines Ecosystems Improved for Sustainable Fisheries project (ECOFISH) was entirely funded by biodiversity funds and managed by the USAID/Philippines mission Economic Growth Office.

- The Oceans and Fisheries Partnership (OCEANS) is entirely funded by biodiversity funds and managed by the Regional Development Mission for Asia.

- The Collaborative Management for a Sustainable Fisheries Future in Senegal project (COMFISH Plus) is funded with Feed the Future funds and biodiversity funds and managed by the USAID/Senegal mission Economic Growth Office.

All activities funded with biodiversity funds must be designed to reduce key threats to biodiversity, and thus have the intent to positively impact biodiversity. Biodiversity-funded projects focus on improving fisheries governance policy and management, including traceability and deterring illegal fishing, for food security, nutrition, resilience, and secure livelihoods. Biodiversity-funded projects conserve critical habitats and ecosystems—upon which healthy fisheries depend—to increase and maintain the productivity of fisheries. While the intent of a biodiversity project is to benefit the environment, there could be situations where specific activities may have the potential for negative environmental or social impacts.

FOOD SECURITY AND ECONOMIC GROWTH PROGRAMMING

Some USAID fisheries projects and most aquaculture projects have been funded by Feed the Future or Economic Support Funds. For example:

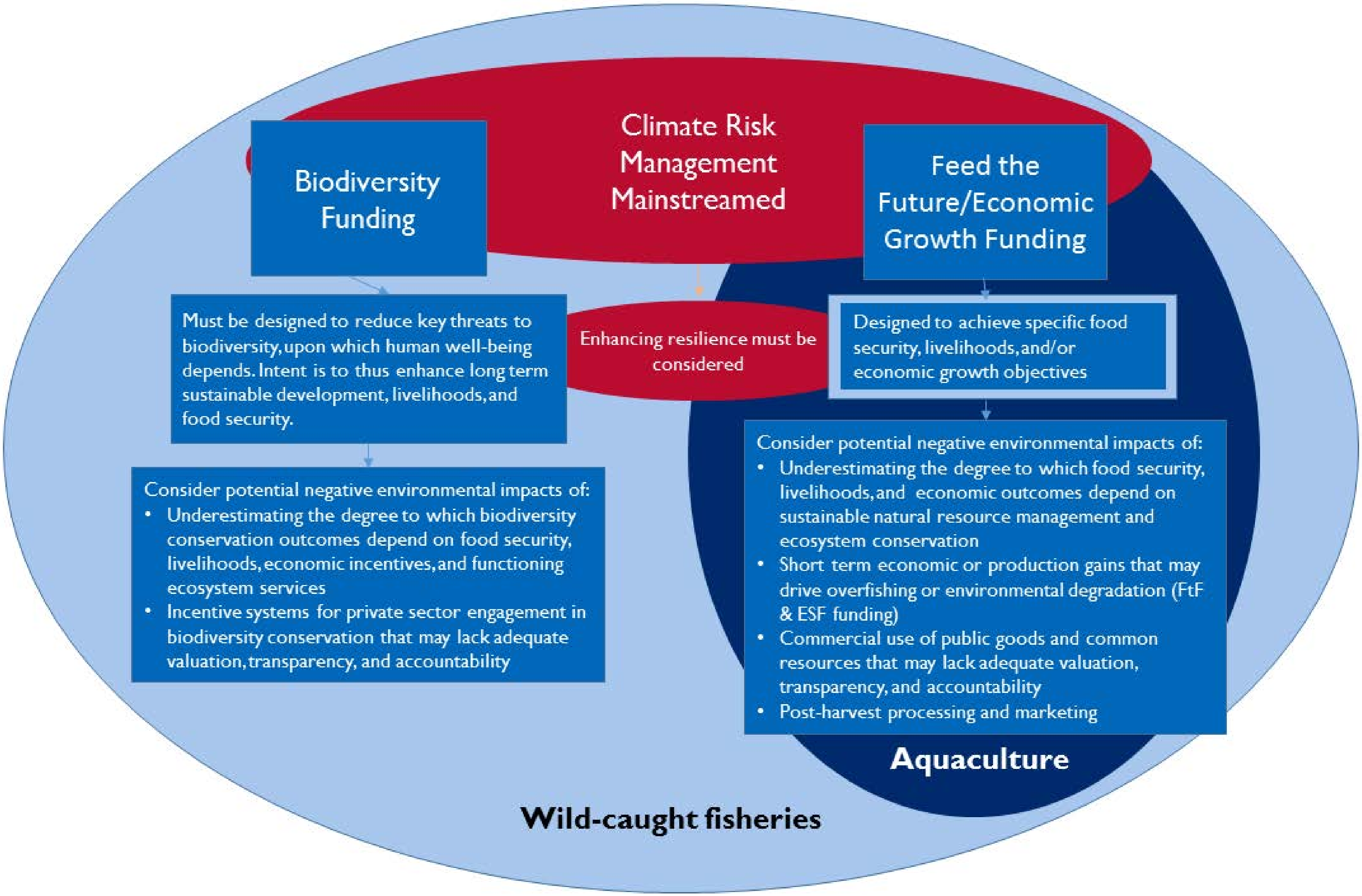
- The Ghana Sustainable Fisheries Management Project (SFMP) is funded almost entirely with Feed the Future funds and is managed by the USAID/Ghana mission Economic Growth Office.

- The Feed the Future initiative overall is led by the USAID Bureau for Food Security in Washington, D.C.

- The Somalia Growth, Enterprise, Employment and Livelihoods (GEEL) project is funded primarily with Economic Support Funds (ESP) and managed by the USAID/East Africa, Somalia Unit.

Projects funded with ESP funds often have short-term objectives. Both Feed the Future and ESP funds have specific food security, livelihoods, and/or economic growth objectives, which may have negative environmental and social impacts if not implemented with strong governance and management for sustainable, long-term resource use and equity of benefits.

Figure 1. Influence of USAID funding source on project objectives and potential negative environmental impacts to consider.

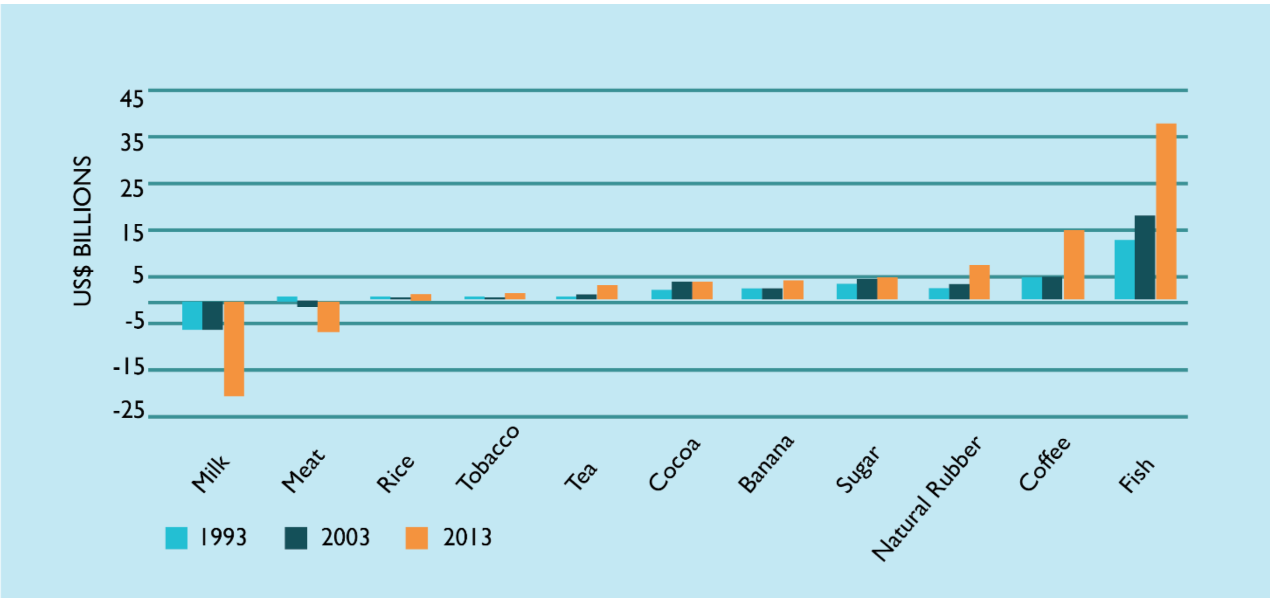


OVERVIEW OF THE SECTOR

Fish, or seafood, is an important food commodity that provides significant employment, economic revenues, and export earnings for many developing countries. Fish and fish products are among the most traded food commodities in the world. Approximately 78% of seafood products are exposed to international trade competition. Over 36% of total fish production is exported—worth US$ 148 billion in 2014. Developing countries' share of the global fishery export value increased to 54% in 2014 and is valued at US$ 80 billion. An increasing share of the international fish trade belongs to developing countries (FAO 2016b). The value of net exports of fish from developing countries is greater than that of rice, sugar, and coffee combined (**Figure 2**). Some developing countries with high per capita consumption are net importers of fish products because the demand far outstrips local supply.

The share of global fish exports from developing countries increased to 54% in 2014 and is valued at US$ 80 billion.

Figure 2. Net exports of selected agricultural commodities by developing countries



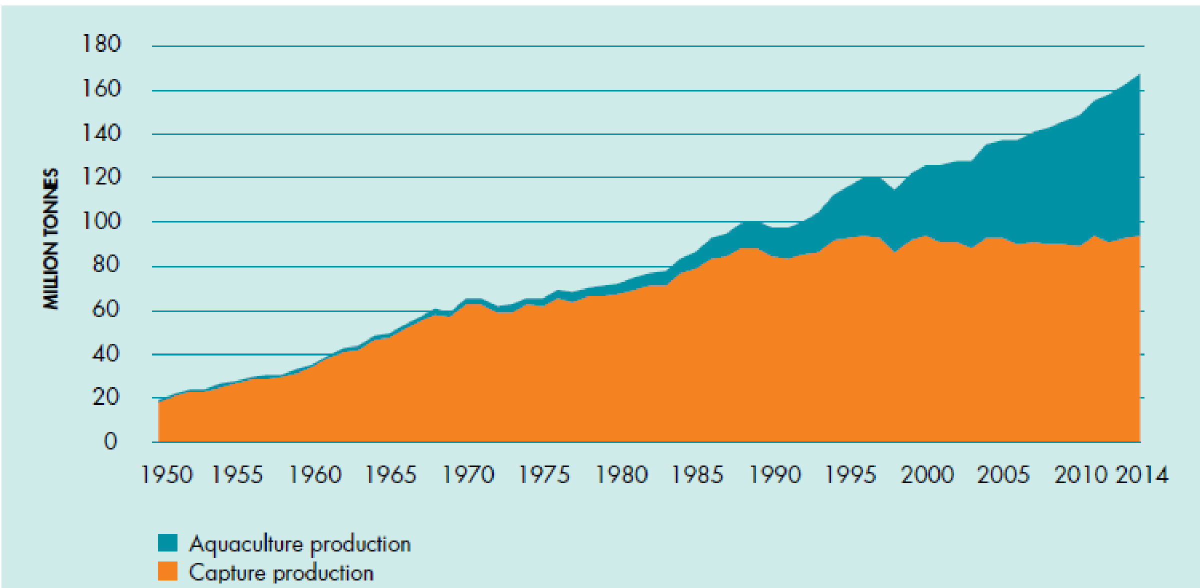
SOURCE: FAO 2016b

The global fish production has grown steadily for decades to a total of 167 million metric tons (MT) in 2014 (***Figure 3***) with fisheries accounting for 93.4 million MT and aquaculture contributing 73.8 million MT. Developing countries account for 78% of the fish food supply globally (FAO 2016b). However, a recent study suggests that the official FAO statistics has underreported the actual fisheries catch. The study estimates that there was a peak of 130 million MT over two decades ago and that catches have declined continuously since then (Pauly and Zeller, 2016). This higher peak is important because it represents the potential productivity that could be achieved with improved fisheries management.

Increasing demand for seafood from developing countries has increased pressure on the sustainability and resilience of both fisheries and aquaculture systems. World per capita fish supply stood at a record 20.1 kg/capita in 2014. This is double the level in the 1960s due primarily to vigorous growth in the aquaculture sector (FAO 2016b). For global seafood availability to meet demand of a projected world population of 9.7 billion in 2050, aquaculture production would need to more than double to 140 million metric tons (Waite et al, 2014). While aquaculture has shown large gains in production, most of that (58%) comes from China. However, the potential for significant growth in Africa and other parts of the world is high.

While fisheries production has leveled off and even declined in recent years, more gains can be made by preventing overfishing and illegal fishing. A recent World Bank report estimates that if overexploited fish stocks were rebuilt, the annual net benefits accruing to the fisheries sector could increase from US$ 3 billion to US$ 86 billion and annual sustained harvests could increase by 13% (76 million MT annually), with most of the needed reform and potential gains in Asia and Africa.

Figure 3. *Trends in World Fisheries and Aquaculture Production*



SOURCE: FAO 2016b

World food fish supply has grown approximately twice as fast as the human population. An increasing amount of the global fish supply is being used for direct human consumption (87% in 2014) as opposed to non-food uses. Until the year 2000, small-scale fishers contributed more food fish for humans than industrial fisheries (Teh and Pauly 2018). Per capita consumption of fish has also steadily increased from 9.9 kg per capita/year in the 1960s to approximately 20 kg per capita/year today (FAO 2016b). Fish accounts for approximately 17% of the global population's intake of animal protein. However, in many developing countries (including key Feed the Future countries) in coastal West Africa, Bangladesh, Southeast Asia, and the Pacific, fish exceeds 50% of the animal protein supply. Fish is a particularly important source of protein as it contains a rich source of micronutrients and vitamins A, B, and D, as well as essential omega-3 fatty acids (Kawarazuka and Béné, 2011). These micronutrients are important in early child development because they improve cognitive function (Oken et al. 2008).

The world seafood supply comes from fisheries and aquaculture. While both sectors provide fish to domestic and international supply chains, they are quite distinct in terms of the means of production and environmental considerations for their development and management. Wild caught fisheries involve managing the sustainable harvest of a natural renewable resource while aquaculture is a specialized form of farming. The U.S. and FAO, as well as some other countries, consider fisheries and aquaculture part of agriculture and they are often managed by one agency as part of an agriculture portfolio. While the production of fish from fisheries and aquaculture is considerably different, the fish produced may be indistinguishable in the post-harvest supply chain.

WILD-CAUGHT FISHERIES

Wild-caught fisheries accounted for approximately 56% of seafood production worldwide in 2014 (FAO 2016b). The sector plays an important role in global and local food security, nutrition, livelihoods, national revenues, and international trade. Sustainable management of fisheries is important from a biodiversity conservation perspective, and healthy, biodiverse ecosystems are important for maintaining the natural productivity of wild fisheries.

THE STRUCTURE OF THE FISHERIES SECTOR

Fish caught from oceans and estuaries are referred to as "marine fisheries" whereas those caught from rivers, lakes, reservoirs are categorized as "inland or freshwater fisheries." The majority of fish are sourced from marine fisheries, accounting for approximately 87% of the total (FAO 2016b). The productive plankton-rich waters of the continental shelf and continental upwelling areas in the nearshore produce high yields of fish. Therefore, most fish catch is from the exclusive economic zones of nation states and under national jurisdiction. However, there are also high seas fisheries, especially for large pelagic species such as tuna that are beyond national jurisdictions and managed by regional fisheries management organizations.

Fisheries production is generated from two main sub-sectors: industrial (or large-scale) and small-scale fisheries. Sustainable certification and traceability programs are more common in the industrial and export sectors, but more and more are being designed for the small-scale sector as well. USAID projects tend to focus more on the small-scale sector as it typically generates more employment and food supply for local markets than the industrial or large-scale sector. However, small-scale fisheries sometimes target export products, and industrial fisheries are often a target for programs trying to address illegal fishing. The two sub-sectors are often in competition for the same resources and hence, both need to be addressed to achieve sustainable fisheries management.

FISHERY / BENEFITS	LARGE SCALE	SMALL SCALE
Subsidies	25-27 billion	5-7 billion
Number of fishers employed	about 1/2 million	over 12 million
Annual catch for human consumption	about 30 million t	same: about 30 million t
Annual catch reduced to fishmeal and oils	35 million t	Almost none
Annual fuel oil consumption	about 37 million t	about 5 million t
Catch per tonne of fuel consumed	= 1-2 t	= 4–8 t
Fish and other sealife discarded at sea	8–20 million tonnes	Very little

Figure 4. A Comparison of Large- and Small-scale Fisheries Sectors.
SOURCE: Jacquet and Pauly, 2008

NATURAL CAPITAL AND ECOSYSTEM SERVICES IN THE FISHERIES AND AQUACULTURE SECTOR

Natural capital describes the naturally occurring assets such as wetlands, mangroves, and coral reefs that provide a wide range of benefit—or ecosystem goods and services—to communities and economies (Hattam et al. 2015). Examples of ecosystem services include habitat for fish, water quality maintenance, and storm surge protection. The loss of critical ecosystem services inevitably results in higher costs for fewer benefits (World Bank 2016). Understanding and assessing these tradeoffs is thus critical to sustainable development.

Maintaining healthy aquatic ecosystems is critical to ensuring continued productivity in the fisheries and aquaculture sectors, and the resilience of those communities and populations that rely on both for income and nutrition. Specific examples of the many ecosystem goods and services associated with fisheries and aquaculture systems are provided in Table 1.

TABLE 1: ECOSYSTEM GOODS AND SERVICES SUPPORTING THE FISHERIES AND AQUACULTURE SECTORS

	Ecosystem Goods and Services	Examples in the Fisheries and Aquaculture Sectors
Provisioning	Food	Fish, shellfish, and seaweed for human consumption.
	Medicinal Resources	Marine-derived pharmaceuticals such as analgesics and anti-inflammatories.
	Ornamental Resources	Shells, pearls, or coral that can be turned into jewelry and decorations.
	Energy and Raw Materials	Algae used for non-food purposes such as fertilizer and energy
	Water Storage	Wetlands and healthy ecosystems mitigate droughts and floods, and maintain environmental flows.
Regulating	Air Quality	The oceans produce 50% of the oxygen we breathe. Healthy coastal ecosystems purify the air of contaminants (dust, foul odors).
	Biological Control	Bivalve filtering coastal water by shellfish may reduce pathogen populations.
	Climate Stability	Marine ecosystems contribute to the global hydrological cycle, extra-regional weather patterns, and local and regional climate. For example, they help moderate temperatures.
	Disaster Risk Reduction	Coral reefs, mangrove forests, and kelp forests dampen and attenuate waves, reducing breaking wave velocity and protecting coastal communities and ecosystems.
	Genetic Transfer	Dispersal of gametes, larvae, and angiosperm by currents and tides support basic reproductive processes and intra-species diversity.
	Soil Formation	Detritus (whale falls) and other nutrients support benthic food webs.
	Sand replenishment	Erosion on coral reefs and calcareous algae supplies sand for beaches, which is good for tourism.
	Water Quality	Nutrient cycling in ocean waters supports healthy marine habitats. Bivalve filtering in coastal waters improves water quality.
	Water Capture, Conveyance, and Supply	Tides move water throughout intertidal zones, supporting intertidal species and habitat. Surface water flows are a major source of water for all terrestrial uses.
	Navigation	Navigable waters enable movement of fishing vessels.
	Habitat and Nursery for Marine Life	Mangroves, seagrass beds, rivers, and coral reefs provide habitats that are critical to sustaining populations of fish and shellfish throughout their life cycles. This includes species that are critical to ecosystem function, but without direct economic or cultural value.

TABLE 1: ECOSYSTEM GOODS AND SERVICES SUPPORTING THE FISHERIES AND AQUACULTURE SECTORS

	Ecosystem Goods and Services	Examples in the Fisheries and Aquaculture Sectors
Supporting	Aesthetic Value	Healthy marine, coastal, and freshwater ecosystems are valued simply because they are visually appealing.
Cultural	Cultural Value	There are traditional and cultural values associated with coastal and marine habitats. Furthermore, there are traditional livelihoods and use of fish, shellfish, and seaweed that are valued because of the history associated with them.
	Recreation and Tourism	Recreational fishing is a popular pastime. Coastal and marine habitats are also popular tourist attractions.
	Science and Education	Research on aquatic ecosystems informs engineering and education. Aquaculture systems are researched for potential innovations, as well as the monitoring of externalities.

FISHERIES' CONTRIBUTION TO EMPLOYMENT

As of 2016, as many as 37.8 million people worldwide were estimated to be directly employed full or part-time in fisheries (FAO 2016b). Other estimates suggest that approximately 260 million people are employed directly and indirectly in the sector and that 78% of those employed come from developing countries. (Teh and Sumaila 2013). Nine out of ten persons employed in fisheries work in the small-scale sector and they catch over half of the fish caught for human consumption (Jacquet and Pauly 2008). In Africa, marine and freshwater fisheries employ 93% of people in the seafood sector, and aquaculture employs the remaining 7%. (De Graaf and Garibaldi 2014).

THE ROLE OF WOMEN IN FISHERIES

Women play an important role in fisheries and usually make up to 50% or more of the labor force (Kleiber et al, 2014). Men are primarily engaged in harvesting at sea, boat building, and engine maintenance and repair. Women are mainly engaged in processing and marketing, but can also be primary producers. For example, women often harvest shellfish and other organisms by walking from the shoreline (referred to as "gleaning"). They also use small dugout canoes in intertidal areas. Some women own fishing vessels and in many countries, they finance fishing trips, thereby guaranteeing a source of fish for their processing and marketing operations.

THE FISHERIES VALUE CHAIN

The fisheries value chain starts from inputs used to harvest the fish on the water, including boats, nets, and human resources. Inputs, in conjunction with appropriate harvesting practices, can affect the productivity, size, and quality of the wild-caught fish, and thus the rest of the value chain. After harvesting, the value chain requires onboard handling and storage, followed by offloading at shore-based or beach landing sites where it is processed or sold fresh to wholesale or retail markets before reaching consumers. Industrial vessels can have sophisticated processing facilities on-board for gutting, filleting, or freezing fish, whereas small-scale fisheries may only bleed, gut, or ice fish before landing on shore and often do not use ice at sea. Onshore processing varies, but for small-scale fisheries, a large volume is sold and consumed fresh, smoked, or dried. Poor onboard handling and processing techniques can lead to large losses in value and quantity of the catch. Onboard handling and processing is an area where significant improvements and value addition can be achieved.

Fisheries management projects sometimes focus only on sustainable harvesting of the fish at sea and instituting governance reforms that move the system towards secure tenure and managed access to fishing grounds, but integrated projects may also consider sustainable harvest controls as well as post-harvest value chain improvements. This can include socially responsible practices, for example, addressing child labor and trafficking of persons, which is a problem in some fisheries.

TRENDS IN FISHERIES PRODUCTION AND LOST ECONOMIC POTENTIAL

As shown in **Figure 3** above, worldwide production from fisheries has seen little growth over the past decade due to poor management and industrial fleets moving from one fishing area to others. Fisheries, as a sustainable and renewable natural resource, must be managed properly to sustain maximum sustained yields. FAO estimates that the proportion of fish stocks that are under-fished has declined to less than 11% in 2013. The proportion of fish stocks considered overfished has increased to 31% in 2013 (FAO 2016b). Fisheries in low-latitude developing countries are most vulnerable to declining catches due to threats such as poor management, illegal fishing, and climate change. Management effectiveness is weakest in low-latitude developing countries (Mora et al. 2009) (see Fig. 5).

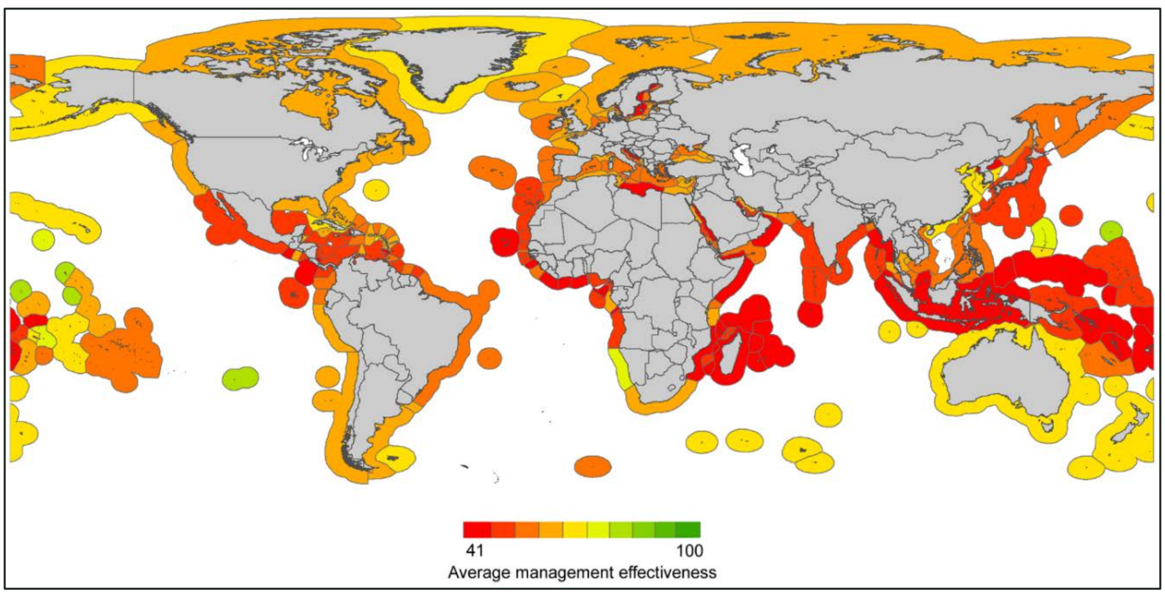


Figure 5. Management effectiveness of the world's fisheries.
Source: Mora et al. 2009

With proper management, it is possible to increase the natural productivity of fisheries. Improved management of fisheries alone can provide an additional 16 million MT of annual fish catch per year (Costello et al. 2016). The World Bank has estimated that with proper management it may be possible to recuperate the US$ 83 billion that is lost annually in the marine fisheries sector, due to depleted fish stocks and excessive fishing effort (World Bank 2017). For example, the USAID/Philippines ECOFISH Project (2012-2017), worked with the Department of Agriculture's Bureau of Fisheries and Aquatic Resources to increase fish biomass by 24% and employment by 12% by improving management of over 1.8 million hectares of municipal waters (USAID 2017).

ECO-LABELING IMPACT INVESTING AND FAIR TRADE

Eco-labeling in the form of third-party certification schemes is growing in the U.S. and Europe due increased demand from retailers and importers for certified sustainable supply chains. Most certification schemes such as the Marine Stewardship Council, are designed for large-scale fisheries in northern countries. A growing number of small-scale fisheries in developing countries are striving to meet certification standards. Certification is costly and most certified developing country fisheries are high-value, export, single-species products. However, the overwhelming volume of fisheries landings in developing countries are lower value products, destined for local and regional markets, where local certification schemes may be more appropriate.

Associated with eco-labeling are fair trade fisheries schemes that seek to ensure environmentally sustainable supply chains, as well as reach social responsibility, economic development, and empowerment standards that benefit local fishers. One example is Fair Trade Seafood: http://www.fishchoice.com/seafood-program/fair-trade-seafood. See also McClenachan et al. (2016) for an overview of the fair-trade concept.

Impact investing is an innovative approach used to promote sustainable fisheries. Impact investing seeks financial capital to invest in organizations, companies, and communities to improve sustainable fisheries supply chains alongside a financial return. One example of this is the Sustainable Ocean Fund (https://rmportal.net/biodiversityconservation-gateway/legality-sustainability/fisheries-development/project-search/add-a-project-activity/sustainable-ocean-fund), which will provide private debt investments in Latin America, Africa, and Asia to sustainable businesses and organizations that catalyze behavior change for sustainable fisheries and generate long-term revenue streams for those involved in fisheries. Another example is the Meloy Fund (https://www.thegef.org/project/ngi-meloy-fund-fund-sustainable-small-scale-fisheries-southeast-asia), which is investing in small-scale fisheries in the Philippines and Indonesia. Principles for Investments in Sustainable Wild-Caught Fisheries (http://www.fisheriesprinciples.org/) were recently released by these impact funds and by multiple donors and organizations and can serve as useful guidance to all fishing investments.

THE SOCIO-ECONOMIC CONTEXT

In many small-scale fishing communities around the world, the fisheries sector is a way of life and there are few alternatives or desire to engage in non-fisheries related livelihoods. Resource-dependent coastal communities are highly vulnerable to overfishing, which can cause significant social and economic hardship and conflict. While the fisheries country context varies greatly from place to place, most USAID fisheries programs are designed to promote sustainable fishing and sustainable livelihoods. They often include components related to post-harvest value chain improvements, livelihood development, combating IUU fishing, improving product traceability, and addressing child labor and trafficking in the sector.

AQUACULTURE

TRENDS IN AQUACULTURE PRODUCTION

In the most recent State of World Fisheries and Aquaculture Report (SOFIA) by the United Nations Food and Agriculture Organization (2016), a number of trends and projections about fisheries and aquaculture production are presented. Key report findings related to aquaculture are as follows:

- Aquaculture is one of the fastest growing world food production sectors. In the decade 2005-2014, aquaculture production grew at a rate of 5.8% per year. World aquaculture production was valued at US$ 160.2 billion and reached 73.8 MT in 2014. At that time, it accounted for 44.1% of global fisheries production for human consumption and other uses. In 2014, worldwide aquaculture production of seafood for direct human consumption surpassed wild capture fisheries for the first time, and production is expected to continue on this trajectory. Worldwide aquaculture production is expected to reach 102 million MT by 2025.
- China, India, Indonesia, Vietnam, and Bangladesh are the top five aquaculture-producing countries, accounting for 82.8% of the global aquaculture production.
- A total of 580 species or groups of species of seafood were farmed globally, including 362 finfishes,[3] 104 mollusks, 62 crustaceans, and 37 species of aquatic plants (seaweeds) among other minor taxa. Inland (freshwater) culture of finfish in earthen ponds involving carps and tilapias is by far the largest contributor from aquaculture to food security and nutrition in the developing world.
- Suitable feeds are widely regarded as a growing constraint to aquaculture growth. About half of the world aquaculture production consists of non-fed species such as seaweeds and microalgae, filter-feeding mollusks, and non-fed finfish including various species of carp such as silver carp, bighead carp, and grass carp.
- Fisheries and aquaculture provided a source of income and livelihoods for an estimated 56.6 million people in 2014. Among these individuals an estimated 18 million (33%) were engaged in fish farming. Of the 18 million fish farmers, the highest concentration is in Asia (94% of all aquaculture engagement), followed by Latin America and the Caribbean (1.9% of the total, or 3.5 million people), and Africa (1.4% of the total, or 2.6 million people). Asia as a whole has pushed far ahead of other continents in raising per capita farmed fish production for human consumption. However, Africa and the Americas, both producing over 16 million MT in 2014 show the fastest regional growth in aquaculture's share of fish food production (see **Figure 6**).

[3] Finfish are fish with backbones such as tilapia or carp, as opposed to invertebrates (or shellfish) such as shrimp, crabs, and oysters.

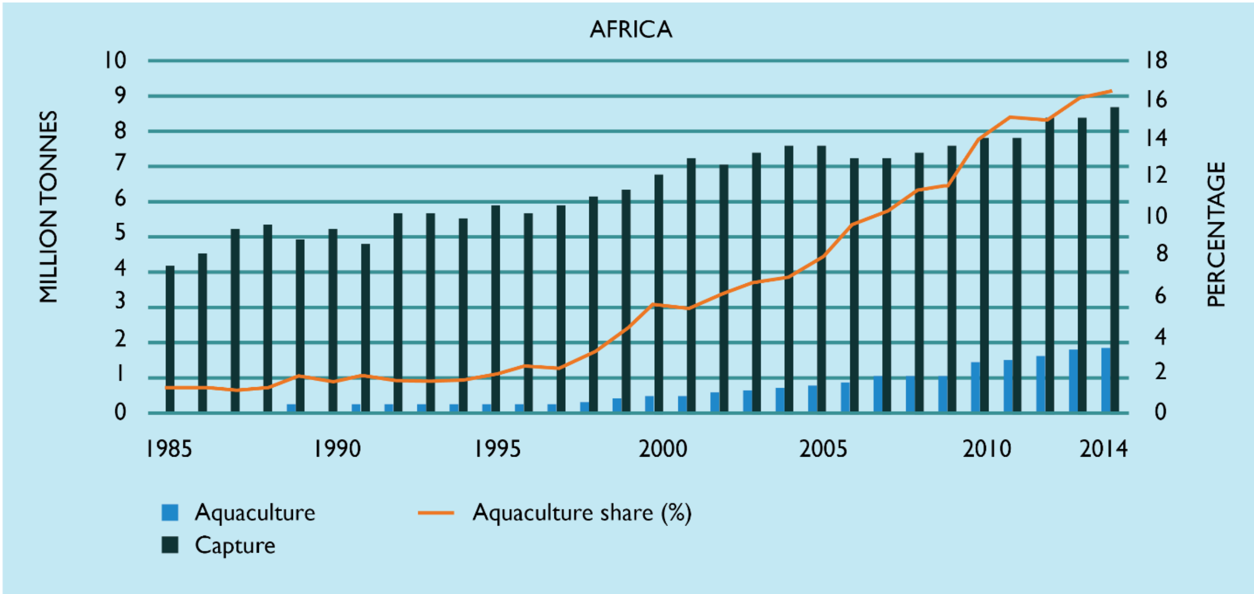


Figure 6: Growth of aquaculture relative to capture fisheries in Africa
Source FAO, 2016 SOFA

COMMON SPECIES CULTURED

Commonly cultured organisms in tropical countries include tilapia, catfish, shrimp, milkfish, oysters, and seaweeds. In tropical developing countries, shrimp is a large export earner whereas tilapia is important for both local food security and exports. Aquaculture occurs in freshwater, brackish water, and marine ecosystems and the type of species grown depends on the ecosystem type and other local factors.

AQUACULTURE PRODUCTION SYSTEMS

While much of the freshwater and brackish water farming is carried out in ponds, there is significant growth in cage culture in rivers, lakes, and reservoirs, as well as in recirculating aquaculture systems. Marine culture of finfish is carried out in cages while seaweed and bivalves (e.g., oysters) use off-bottom trays, rafts, and bottom-culture methods. Aquaculture includes fish that require feeds as inputs (e.g., salmon, tilapia, and shrimp) and those that do not require feeds (e.g., oysters and seaweeds, which filter their nutrient needs from the water). Farmed fish such as tilapia tend to have better feed conversion ratios (the estimated feed required to gain one pound of body mass) than most other farmed animals (**Figure 7**) and they produce fewer greenhouse gas emissions. Carnivorous fish such as salmon and grouper tend to have higher feed conversion ratios than tilapia and milkfish. Feed conversion ratios are an important measure of farming efficiency, and since some feed is based on wild-caught fishmeal, there are environmental concerns regarding sustainability. Some farming systems, such as tilapia and milkfish, do not require feeds. These types of fish can be grown in ponds solely using fertilizers to create plankton for feed. The lowest impact aquaculture systems are those that require no feed inputs such as oysters or seaweed. These aquaculture products receive all their nutrient requirements from the water column.

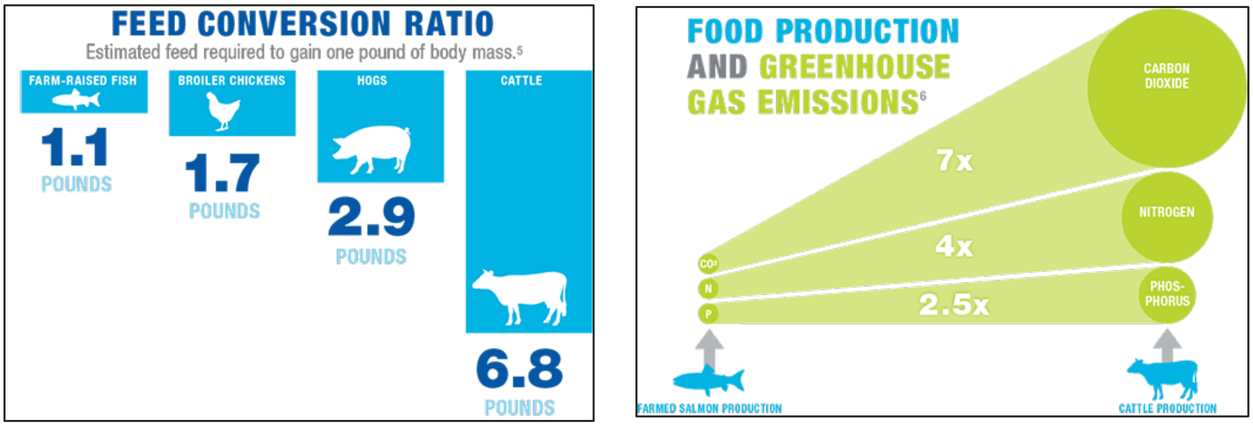


Figure 7: *Feed conversion efficiency of various farmed animals*
Source: Global Aquaculture Alliance (https://www.aquaculturealliance.org/what-we-do/why-it-matters/)

Aquaculture can also be classified as intensive or extensive production systems. Extensive systems have low seed-stocking densities, minimal if any feed requirements, and produce low yields per hectare. Intensive systems have high seed-stocking densities, high feeding requirements, and often require special aeration and filtration systems. Intensive systems have higher yields per hectare, but are often more susceptible to disease. Intermediate or semi-intensive systems are often recommended because they minimize disease risks, require moderate inputs, and can provide higher yields than extensive systems.

Aquaculture systems can be classified as open or closed cycle. Open systems rely on open water exchanges with a river or estuary. They risk disease transfer to wild populations, as well as hybrid or non-endemic species being released to the natural environment. Closed systems such as recirculating aquaculture systems (RASs) can be built inside warehouses and recirculate water with only occasional wastewater discharges or external water intake. Closed cycle systems can also refer to the farmed organism's reproductive system whereby the life history and farming system does not rely on the use of wild broodstock or fingerlings for breeding and stocking. Closed cycle systems tend to have fewer potential environmental impacts.

While USAID fisheries programs focus on restoring and enhancing the productivity and sustainability of wild-caught fisheries, aquaculture programs focus mainly on increased production and addressing issues of seed quality (i.e., quality of the strain of fingerlings stocked in ponds), disease management, and feeds. Aquaculture development programs that establish and expand production areas require careful attention to environmental concerns.

Third-party certification schemes are common in aquaculture. One example is the Aquaculture Certification Council (https://bapcertification.org/), which applies "best aquaculture practices" and certifies farms, processing plants, and feed and seed producers for environmental sustainability, social welfare, food safety, and animal welfare criteria.

POTENTIAL ADVERSE IMPACTS OF THE FISHERIES AND AQUACULTURE SECTORS

FISHERIES IMPACTS

Potential impacts of USAID programs in the fisheries sector are similar for freshwater and marine systems. However, the unique characteristics of each ecosystem, the type of fishery, and the technologies used needs to be considered in predicting the impacts.

OVERFISHING

Overfishing occurs when there is excess fishing capacity available to harvest a sustainable maximum biological or economic yield of fish. Overfishing reduces the size of the stock in a body of water and eventually reduces the potential yields that can be harvested on an annual basis. The goal of most fisheries management programs is to prevent overfishing and sustain or rebuild stocks at levels that produce maximum yields or catch of fish.

Overfishing is a common result of open access to a fishery where entry is not sufficiently controlled or where other management measures are not sufficient to control capacity. In open access situations, which are the norm for most small-scale fisheries, capacity can be controlled by, for example, limiting the number and size of vessels and gear. However, even with a limited number of boats, vessels can increase effort by spending more days fishing and increasing the crew size, size of gear, and size of engines.

Overfishing affects the structure of the entire marine ecosystem (Pauly et al. 1998; Myers et al. 2007). When overfishing occurs it can have negative effects on species diversity, create changes in ecological trophic structures, and have unintended cascades on other aquatic life (Jackson et al., 2001; Daskalov et al., 2007).

SUBSIDIES

Fishing subsidies can cause or exacerbate overfishing. They are a common practice in developed and developing countries alike. Fishing subsidies can take many forms and can be grouped into positive, negative, or neutral subsidies. Positive subsidies enhance fisheries management and include investments in scientific stock assessments and fisheries enforcement capabilities. Neutral subsidies are those that have no effect on fishing effort. Negative subsidies are typically input subsidies for fuel, gear, or vessels.

Negative subsidies distort markets, reduce the costs of fishing, and drive overfishing. In open access regimes, these subsidies allow more vessels and effort to be used and thereby exacerbate overfishing. It can be argued that where sufficient effort or catch controls are in place, or where fisheries are underdeveloped and not fully exploited, input subsidies will not exacerbate overfishing (Porter 1998; Cox and Sumaila, 2010). However, few developing countries have been able to implement catch controls or quota-based systems for their industrial fleets or small-scale fisheries. Though fewer and fewer fisheries are underexploited (FAO 2016b), developing countries often use input subsidies as a strategy to maintain employment and incomes of fishers, and thus curry votes, in spite of potential impacts on sustainability of the fishery (Milazzo 1998; Schubauer et al., 2017). Input subsidies are popular politically and difficult to remove once instituted. Subsidies in fisheries have also become a contentious topic in World Trade Organization negotiations where many experts recommend phasing out negative subsidies (Sumaila and Pauly 2007). In some cases, input subsidies are viewed as supporting illegal fishing as they support distance water fleets operating far from home. The position of the U.S. government is to support the prohibition of harmful fishing subsidies during World Trade Organization and trade agreement negotiations.

FUEL CONSUMPTION AND ITS IMPACT ON CLIMATE CHANGE

An analysis of global fisheries' energy use based on figures from 2000 found that fisheries accounted for approximately 1.2% of global oil consumption, burning on average 620 liters of oil per live weight ton of marine fish and invertebrates landed (Tyedmers et al. 2005). Consequently, fisheries emitted an estimated 134 million tons of CO_2 into the atmosphere, primarily from fishing vessels (Tyedmers et al. 2005).

The type of gear used and type of fish targeted influence energy efficiency in fisheries (**Figure 8**). Small pelagic, finfish, and mollusk fisheries have lower fuel intensity than large pelagic and crustacean (e.g., shrimp) fisheries. Gill nets and hook and line fisheries are more efficient than bottom trawls and pots and trap lines. There is conflicting evidence as to whether small-scale fisheries are more fuel efficient than large-scale fisheries (Berkes and Kislalioglu, 1989). Gear type and target species seems to be a better determinant of fuel efficiency.

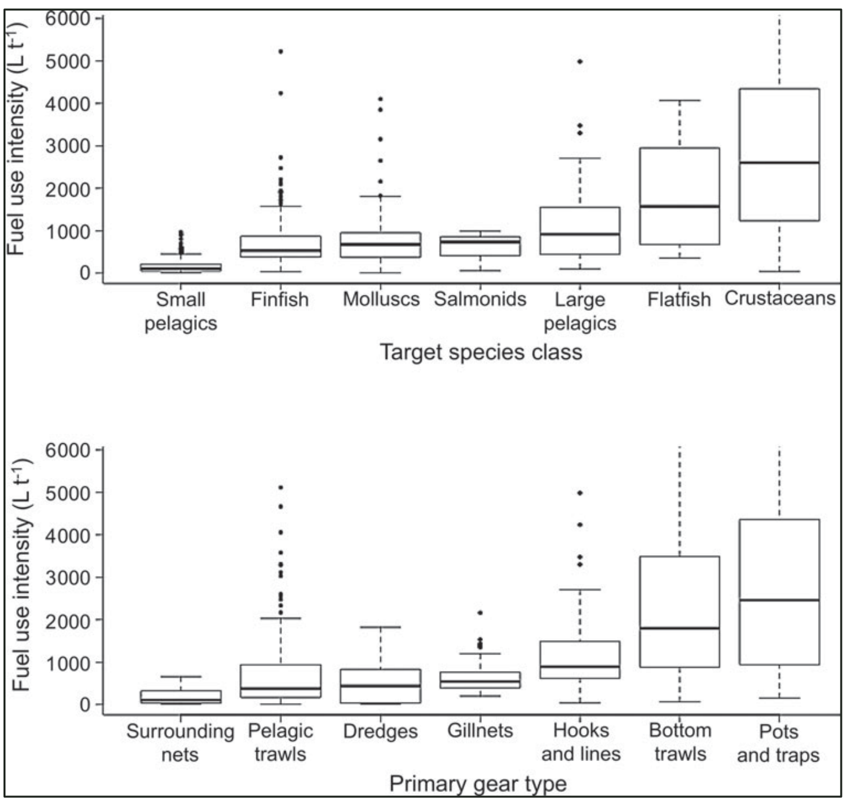


Figure 8. *Fuel use intensity relative to gear type and target species*
SOURCE: Parker and Tyedmers 2015

Changes in fisheries due to climate change may also affect fuel use efficiencies. For instance, if warming waters cause fish to migrate further out to sea, that could result in increased fuel use per kilogram of fish harvested. Hence, fisheries management policies can have impacts on fuel efficiency and the emission of greenhouse gasses.

CAPTURE OF ENDANGERED, THREATENED, AND PROTECTED SPECIES

Endangered, threatened, and protected (ETP) aquatic and marine species such as marine mammals (dolphins, whales), turtles, sea birds, and sharks can be impacted by use of fishing gear that intentionally or unintentionally captures these species. Endangered species of sharks, marine mammals, and sea turtles are particularly susceptible to drift gill nets. Surface gill nets can also entangle sea birds that dive into the water to feed of fish caught in the nets. Trawl nets can capture sea turtles, which drown before the catch is hauled up to the boat.

DESTRUCTIVE FISHING PRACTICES

Destructive fishing practices refers to practices that indiscriminately damage or destroy habitat or fish populations (Russ and Alcala 1989; Harborne, et al., 2017). Examples include bottom-trawling, the use of explosives such as dynamite, and the use of chemicals, such as cyanide. Homemade bombs or actual explosives are used to stun and kill fish in the water. The fish are then harvested with nets. Bomb fishing damages coral reefs by breaking coral colonies that are very slow growing and could take decades to recover. Bombs also indiscriminately kill all fish in the vicinity of the blast, including small juveniles and species that are not targeted by the fishers. Many fish float to the surface, but others sink to the bottom and are not recovered by fishers. In most countries this practice is banned.

Use of chemicals such as cyanide for fishing also falls into destructive practices. Cyanide, which is commonly used to stun and collect live fish for aquariums and restaurants is harmful because it kills coral reefs. While there is little evidence of poisoning among people that eat cyanide caught fish, there is a risk – especially among those that ingest a lot. Another example is trawl fishing, which can damage seagrass beds, patch reefs of soft corals, and coral reefs by using dragger chains on the bottom of the net (McManus 1997; Pitcher et al. 2016). Liners are often placed in the bag end to catch very small fish and to cheat on minimum mesh size regulations. Due to these environmental concerns, bottom trawl fishing is banned or and regulated in most countries.

ILLEGAL, UNREPORTED, AND UNREGULATED FISHING

Illegal, unreported and unregulated (IUU) fishing, robs the world's oceans of 26 million tons of seafood annually, bringing financial losses to a staggering US$15 to US$36 billion a year (http://www.gfintegrity.org/report/transnational-crime-and-the-developing-world/ (https://www.fish-i-africa.org/all-publications/). IUU fishing has been gaining increasing attention from the United States government as a threat to national security, food security, and stability (see: http://www.nmfs.noaa.gov/ia/iuu/iuu_overview.html). While illegal fishing in developing countries is a problem in both the small-scale and industrial sectors, the industrial sector presents particular challenges.

Illegal fishing severely affects the livelihoods of fishers and other fisheries-sector stakeholders and exacerbates poverty and food insecurity. It undermines the accuracy of fisheries' stock assessments and fisheries management and threatens the stability of coastal communities that rely on fish as a source of food and livelihoods. Illegal fishing is an undermines effective national fisheries control and management, global trade, equity, and the ecosystem, yet it continues to spiral and grow disproportionately in the exclusive economic zones of developing countries. Understanding and mapping IUU networks, pathways, beneficiaries, hot spots, and business models of modus operandi are critical to improved strategies of enforcement and control.

OTHER HARMFUL FISHING PRACTICES

The use of fine mesh nets is common in small-scale fisheries. Fine mesh nets, which capture high proportions of juveniles, are considered harmful because they do not allow enough juveniles to reach maturity and reproduce. In some cases, mosquito bednets are repurposed into fishing nets, including many donated treated bed nets from malaria prevention programs (such as in Lake Victoria). Hence, program activities from another sector can spillover and have negative impacts in the fisheries sector. Many beach seines also use fine mesh nets with the same impact on larval and juvenile stages of many aquatic species. Additionally, drift gill nets catch large numbers of turtles, marine and aquatic mammals, and other threatened species indiscriminately (Reeves et al. 2013).

Some programs have adopted net replacement programs where the destructive gear can be turned in for a more environmentally friendly gear. However, these programs must be designed carefully because sometimes fishers turn in old worn nets that are at the end of their productive use. In those cases, the net replacement becomes a subsidy for new nets, which may reduce destructive fishing but still contribute to overfishing—too many nets chasing too few fish. There have also been cases where new gill nets, intended for offshore pelagic species believed to be underexploited, were used to target sea turtles for a lucrative but illicit trade in turtle meat and shells.

IMPACTS ON NATURAL CAPITAL AND ECOSYSTEM SERVICES

The fisheries sector is especially dependent on the ability of aquatic ecosystems to provide habitat for the fish species being harvested, as well as their food sources, and any other species that support the stability and resilience of those ecosystems (Harvey 2001). Ensuring the long-term productivity of a fishery requires an understanding of these relationships, as well as an ongoing awareness of the general health of that ecosystem as a whole—focusing on species in isolation may ignore critical food web dynamics (Mormorunni 2001). Each produces a different (though overlapping) bundle of ecosystem services, based on the ecosystem functions present in each. For a complete mapping of ecosystem goods and services to negative impacts within capture fisheries and aquaculture, please see Annex II.

Ecosystem services are critical to both wild caught fisheries and open aquaculture systems. Overfishing and bycatch degrade the ecological and economic viability of capture fisheries, reducing natural productivity, genetic diversity, reproductive rates, or growth and maturation processes, all of which threaten food security. Abandoned fishing gear (a.k.a., ghost nets), collisions with sea life, and use of toxic substances (e.g., cyanide) all degrade provisioning ecosystems services.

Over-harvest of low-level food web species (e.g., krill, anchovies) for aquaculture feedstock may impair the larger food webs, which capture fisheries rely on. Introduction of exotic or invasive species for aquaculture may also lead to direct predation on commercially or culturally significant species. Finally, aquaculture systems may divert scarce water from natural systems and direct human use.

Regulating and supporting services provide a foundation for provisioning services. Overfishing and overharvesting may disrupt the food web in ways that allow aggressive feeders (e.g., sea urchins) to decimate ecosystems. This affect is known as a trophic cascade, where removing top predators such as sharks can reduce productivity of seagrass meadows and coral reefs. Trawling may damage habitat for lower-level aquatic food web (e.g., eelgrass, benthic communities) that support the food chain. Destruction of reefs, shoals, and nearshore habitat may harm critical breeding and nursery habitat for commercial and other critical species. Shipwrecks and fuel and oil spills may degrade water quality locally or regionally, while lost fishing gear may reduce natural productivity of habitats, foul boat propellers, or even present a navigational hazard.

Converting mangrove and other wetland ecosystems to aquaculture disrupts soil-building processes (important for carbon sequestration), and often leads to significant erosion, reducing storm surge protection for coastal communities. Overstocking aquaculture pens allows pathogenic organisms to thrive, but suspended solids often degrade water quality. Excess nutrients often producing algal blooms and eutrophication, which in turn reduces dissolved oxygen in both natural and cultivated systems.

The cultural services provided by marine and freshwater ecosystems are often key to local economic resilience. Coral reefs and clean beaches have strong appeal to both tourists and local residents, often supporting significant recreational economies. Overharvesting for commercial markets or subsistence can seriously degrade not only ecosystem function, but also the aesthetic appeal for both tourists and residents. Poorly designed aquaculture systems may impact recreation, as well as displacing traditional livelihoods.

Finally, the adverse impacts may also interact with climatic changes to exacerbate these effects (Vermeulen 2014). For example, if there are changes in natural fish migration due to changes in water temperature at the same time as there is overexploitation, the result will be an even greater reduction in fish abundance in the area where the fish are migrating from.

SOCIOECONOMIC IMPACTS RELATED TO FISHERIES MANAGEMENT

While the emphasis of this guide is on potential environmental impacts, program designers must also be cognizant of possible socio-economic consequences of proposed activities. Designers need to ask who will benefit from the interventions—will they benefit the poor and/or shift power dynamics? How will the interventions target and benefit vulnerable households and groups? If an activity incorporates gender equity objectives, care should be given to prevent elite capture of benefits or disadvantaging women. In addition, forced child labor and human trafficking is a known problem in small-scale local supply chains as well international and industrial supply chains. Program designers need to be cognizant of—and address or at least take action not to exacerbate—these issues.

AQUACULTURE IMPACTS

Environmental and social impacts are often related to lack of good management at the appropriate scale. They may occur as a consequence of inappropriate design, site selection, construction, farm operations, and/or processing and other supply chain activities. Many impacts such as disease outbreaks, water diversion and use, and habitat loss and degradation, are cumulative over time. Responsible aquaculture requires not only consideration of impacts at the farm level, but cumulative impacts at the larger landscape and watershed scale. Expansion beyond a system's carrying capacity will have negative consequences even with well-run individual aquaculture operations (Beveridge. 1984; McKindsey et al. 2006). One example is large-scale fish die offs in enclosed water bodies (e.g. bays, small coves, and lakes) where excessive permitting of fish cage culture farms resulted in too much organic loadings from feed and fish excrement. That, in turn, resulted in anoxic water conditions leading the fish to suffocate and die in a matter of one day (Rice and DeVera. 1998; San Diego-McGlone et al. 2008). These dies offs led to millions of dollars of lost production. The die offs also have down-stream impacts on feed suppliers, processors, and marketers. Thus, one needs to be aware of cumulative impacts, not just of disease, but large-scale water diversion and habitat loss. Potential impacts can be characterized qualitatively, but it is best if they can be quantified and monetized as well. Quantification and monetization are valuable tools because they support consideration of net impacts (Hanley et al. 1998). Fish feed management can also have considerable impact on the sustainability of fish cage aquaculture (Cho et al. 1994).

The type of potential impacts of aquaculture development depends on the type of farming system—whether it is an open or closed system and whether it is a pond, cage, or bottom culture in a natural environment. The type of species farmed and use of feeds or not also matter (Boyd et al. 2008).

HABITAT LOSS, DEGRADATION, AND CHANGE

Potential habitat loss and change is an important consideration in the siting and construction of aquaculture farms and facilities. Many brackish water areas have seen large-scale conversion of mangrove forest ecosystems for the development of shrimp ponds. It is one of the primary causes of mangrove habitat loss and has led to extensive destruction of mangrove systems especially in Southeast Asia and Latin America (Primavera 2006; Berlanga-Robles et al. 2011). Mangrove ecosystems produce critical ecosystem services (e.g., coastal protection from storm surges, disaster mitigation, nursery habitat for pelagic and demersal species, and carbon storage and sequestration). Some of these benefits accrue locally (e.g., disaster mitigation), while others are indirect, such as essential fish habitats that generate estuarine dependent fisheries yields. Habitat loss and degradation are not only a concern for pond development, they can also occur because of excess cage culture densities that impact water quality and associated aquatic vegetation (Cromey et al. 2002). Additionally, stake and line methods of seaweed farming alter bottom habitats and impact seagrass, coral reefs, and reef flat habitats. Some bivalve farming structures can alter bottom habitats by increasing sedimentation of rivers and estuaries (Bindu and Levine 2011; Kaiser et al. 1998). Cage culture or floating systems in natural water bodies, if in dense enough quantities, may affect and impede water flows of some systems. Excess feed use can also degrade bottom habitats.

DIVERSION AND WATER FLOW CHANGES THAT IMPACT DOWNSTREAM USERS AND ECOSYSTEMS

Although small-scale and sustainable aquaculture can be designed to use very little water, many forms of aquaculture require a large amount of water to be productive. Inland and brackish water pond systems require diversion of water into the systems to fill the ponds and flush them of waste. Water diversion from small streams and rivers can be significant, especially in low rainfall and flow periods. An additive impact of extensive pond development is reduced water flow downstream from aquaculture operations. Intensification of aquaculture operations and integrated agriculture-aquaculture systems may be considered as a strategy to conserve water resources (Ahmed et al. 2014). Water diversion can reduce the productivity of natural ecosystems and disrupt other natural resources-dependent livelihoods. Thus, water use and productivity should be considered at a watershed scale.

WATER POLLUTION

Sustainable aquaculture farms follow best management practices that calculate the correct amount of feed to administer so there is little or no fecal matter buildup. However, some systems that are not fully closed will discharge waters to adjacent water bodies to eliminate buildup of waste or for water exchange when dissolved oxygen levels may be low. The discharge may have high levels of nutrients that can affect the aquatic environments of local water bodies, contributing to algal blooms and die-off of submerged vegetation from lack of sunlight, as well as discharge of farm pathogens into the natural environment (Banas et al. 2002). Die-off of submerged vegetation will also contribute to increased BOD and further algal blooms causing a negative feedback loop and can impact native fish populations. Excessive nutrient loading can reduce dissolved oxygen levels and result in die offs of aquatic organisms including fish. Hence, discharge and associated water pollution are a concern when feed is used in the growing process. Some closed systems that use tanks also discharge water from time to time, leading to nutrient, pesticide, and/or pathogen contamination. Feed management and consideration of cumulative impacts of multiple farms and carrying capacity are important to prevent water contamination from pond discharges (Hlaváč et al. 2014). Another risk is when fish farms use chemicals and pesticides to kill pathogens or predatory species when preparing ponds before stocking. This may contaminate the water body with discharges of pond water. It is recommended that biodegradable or photodegradable pesticides be used for pond preparation activities and that discharges occur only after non-toxic levels are reached (Anyusheva et al. 2012).

INTRODUCTION OF NON-ENDEMIC AND INVASIVE SPECIES TO WILD SYSTEMS

Aquaculture can potentially involve culturing non-native species. For instance, the most widely used tilapia species (a native species from Africa) is not native to most of the world. However, it can now be found in virtually every freshwater aquatic system around the world due to its extensive promotion as the aquatic equivalent of chicken. Virtually anything that is cultured in a pond or cage, and even closed tank systems, is vulnerable to accidental escape and possible introduction into the natural environment. Non-natives species can become invasive and displace native species as the dominant type in local systems. They can also have food web cascades (DeSilva et al. 2009), which in turn can impact other livelihoods such as fishing. However, in some cases, such as the recent accidental introduction of the invasive charru mussel into the Philippines from South America, the introduced species may have potential as a fisheries species. In the Philippines, the charru mussel quickly became commercially exploited by shellfishers and mussel farmers, even though it was considered a pest by some oyster farmers (Rice et al. 2016).

The following factors are important when selecting a species to culture:

- Is it a native species? If non-endemic, what are the potential risks from becoming invasive? Can adequate levels of safeguards be established? Is the species low on the trophic level?
- Are there well-established hatchery techniques or will the aquaculture operation be dependent on wild-harvested larvae, fry, or juveniles?
- Does the species thrive in crowded spaces/captivity? Is the species capable of rapid and uniform growth (which will ensure efficient use of facilities and food)? Is the fish cannibalistic? (If so, it is likely to reduce the survival rate.)

- How efficient is the food conversion ratio (i.e., the ratio of dry weight of food to the wet weight gain of fish)? Does the species need artificial feed and if so, is the it amenable to artificial feeding? (Fish lower in the food chain may not need artificial feeds.)
- How hardy and disease resistant is the fish? Can it survive in sub-optimal conditions (e.g., high/low temperatures, low dissolved oxygen, high pH, low/high salinity)?
- Is the fish marketable and is there local and/or international demand for the species?
- What is the level of meat recovery? Species with a large proportion of meat relative to the total body weight are most desirable.

INTRODUCTION OF DISEASES, PARASITES, AND PATHOGENS TO WILD POPULATIONS

Biosecurity is another concern, where diseases in aquaculture systems along with pathogens, predators, and parasites can be released into the ecosystem, with adverse effects on fisheries, coral reefs, and other species. Importation of brood stock or seed stock is also a concern because if the stock is not quarantined properly it could bring in new diseases, pathogens, and parasites that affect the local brood stock and native species if the imported stock escapes into the natural environment. Even when native species are cultured, if the strain is a captive bred and escapes into the wild and interbreeds with wild strains, there are concerns about potential genetic dilution of wild strains. When the potential risks of diseases and pathogens carried by aquaculture are known, spatial planning may be used to mitigate impacts on wild fish populations (Gentry et al. 2016).

USE OF UNDERUTILIZED FISH BYCATCH FROM FISHERIES AND FISH MEAL AS A PROTEIN SOURCE IN FISH FEED

As discussed earlier, cage culture of high-value carnivorous fish species in tropical waters often uses underutilized fish bycatch from the capture sector as a feed source. While this may be considered efficient utilization of a bycatch with low value and no direct human consumption, use of bycatch and wild fish promotes sustained rates of fishing effort in degraded fishery ecosystems. This prevents fishery recovery and can disrupt ecosystem functions. If the fish used in fish meal originates from subsidized trawling fleets, it creates demand and increased pressure to target stocks that have been overfished. In cases where overfishing is mainly caused by excessive trawl fishing, the elimination of fish meal markets would make trawling unprofitable. This would lead many trawlers to go out of business, which in turn would reduce fishing effort. The use of well-formulated fish feed, or the culture of species that do not require any feed, is preferred as they will almost always have better feed conversion ratios than trash fish.

Fish meal or fish oils originate from the wild harvest of fish species such as sardines, anchovies, and other small pelagics, which are high in oil and fat content. The fish are processed and reduced to fish meal that goes into feeds for cultured finfish, shrimp, and other livestock. The harvest of small pelagics for fish meal may limit the fish and protein available for local consumption. It may also drive up demand for and price of captured fish, which in turn may fuel overfishing (e.g., Naylor et al. 2000; Davis et al. 2005). Overfishing of "forage fish" is a growing concern as small pelagics are critical components of natural food chains (Pikitch et al., 2012). In the last 20 years, there has been considerable progress in aquaculture feed development, substantially reducing the requirement for fish meal (Hansen et al., 2007, Moutinho et al., 2017). Use of feeds with high vegetable or other innovative sources of protein such as insect meal (Sanchez-Muros et al., 2014) should be strongly encouraged. Projects should avoid promoting development of fish meal plants as well as the use of wild fingerlings or juveniles for seed stock.

Some aquaculture operations rely on a wild source of juveniles or fingerlings as seed stock for their operations. Examples include tilapia, salmon, grouper, lobsters, milkfish, sea cucumbers, and shrimp. In some cases, such as lobster, the research and development of technology and processes to allow for a closed breeding cycle do not yet exist. In other instances, closed breeding cycles have been successfully implemented, but are not yet cost effective at producing juveniles for stocking in ponds or cages at scale. In yet other cases, there may not be an available supply of hatchery-raised seed stock in the growing area. Where seed supply from hatcheries is not available, a demand is created for a fishery for juveniles that are then grown out in cages or ponds. Generally, harvesting of juveniles from the wild is a bad fishing practice that affects the heath of wild stocks (Hair et al. 2002).

POST-HARVEST IMPACTS FROM PROCESSING PLANTS AND OTHER SUPPORTING INFRASTRUCTURE

The potential for environmental impacts of post-harvest interventions are similar for aquaculture and wild caught fisheries. Once the fish is transported off the boat or from the pond or cage, it enters a supply chain that ends on the consumer's plate. Improvements in small-scale infrastructure for sorting, cleaning, icing, display, and sale of fish or construction of small-scale processing plants may be included in projects. Improvement in small-scale processing is a good way to add product value and quality, generating increased profits for small-scale fish processors which typically are small- and medium-scale women-owned enterprises. It also can contribute to improved food safety with cleaner, fresher, and more nutritious fish food products provided to local markets. However, proper management and regulation of total processing capacity—in both small- and large-scale fishing and fish farming—is needed to ensure that the demand for fish by processing facilities does not exceed the carrying capacity of fisheries and aquaculture facilities.

DEVELOPMENT POST-HARVEST FACILITIES

Development of shore-based post-harvest handling and processing infrastructure has the same general environmental concerns as any small-scale infrastructure development, including selection of facility siting in non-hazardous zones and avoiding wetland or mangrove forest areas. Facility renovation and construction could disturb existing landscapes, habitats, and sensitive ecosystems; degrade water resources; cause sedimentation to surface waters; and contaminate groundwater and surface water. Runoff from cleared ground or materials stockpiled during construction can result in sedimentation/fouling of surface waters. Construction may result in standing water on-site, creating breeding habitats for mosquitoes and other disease vectors. Local procurement of construction materials (e.g., timber, fill, sand, and gravel) may have adverse local impacts. In coastal areas, construction of fish processing and landing facilities requires consideration of proper setback from the high-tide line in erosion-prone areas and away from estuarine flood zones. Sea level rise means increasing rates of erosion and flooding, which also needs to be factored into facility siting and local zoning procedures. For guidance on small-scale construction activities see: http://www.usaidgems.org/Sectors/construction.htm.

WATER AND SANITATION ISSUES RELATED TO LANDING AND POST-HARVEST PROCESSING SITES

Processing and landing beach infrastructure require proper drainage and disposal of waste with high organic loads to avoid pooling of water that can breed mosquitoes and flies, in turn creating health impacts (Dwyer et al., 2016). Typically, such facilities are accompanied with water supply, toilets, and showers for people—requiring safeguards of handling runoff and waste. Withdrawal of excessive amounts of fresh water may exacerbate saltwater intrusion into the local aquifer (Klassen and Allen, 2015). Fish processing plants, even small-scale plants, tend to generate large amounts of organic liquid and solid waste effluents, which must be properly treated and not discharged untreated into nearby receiving water. Hence, this type of beach infrastructure needs proper waste storage and disposal capabilities (Muthukumaran and Baskaran, 2013). For a review of environmental guidelines on water and sanitation and solid waste management see: http://www.usaidgems.org/Sectors/watsan.htm and http://www.usaidgems.org/Sectors/solidWaste.htm.

IMPACTS RELATED TO SMOKING AND OTHER FISH PROCESSING

Smoking fish may have safety and health risks for fish processors. Depending on the type of oven used, smoking fish can add high concentrations of polycyclic aromatic hydrocarbons (PAHs), which are carcinogens, into the final product (Tongo et al., 2017). Fish processing may also generate odor pollution. Additionally, inefficient smokers that use wood can contribute to deforestation, especially in the absence of proper management of wood sources. As previously discussed, when the overall catches decline, processing plants that convert wild-caught fish to fish meal may see a decrease in available fish. This disrupts the livelihoods of small-scale seafood processors.

Increasing the value of fish products through improved processing, packaging, and marketing, means increased fish prices at the retail level. This can in turn drive up the price of fish sold off the boats. The increase in demand for the raw product may create an incentive for increasing efforts in an attempt by fishers to earn more profits. Increased effort spurring additional pressure on exploitation can exacerbate overfishing and ultimately result in dwindling landings of fish (Brush et al., 2009).

INTERACTIONS BETWEEN FISHERIES AND AQUACULTURE

There are many interactions between fisheries and aquaculture in the post-harvest supply chain (Alongi, 2002). One concern in the aquaculture sector is the use of fish meal, which is described in the aquaculture impacts section. There is an argument that wild-caught and low-cost fish should be reserved for direct consumption in poor nations. The anchovy stock and other forage fish are also important because they help sustain healthy coastal ecosystems and fish such as sharks and tunas (Pikitch et al. 2012).

The amount of wild-caught fish used for the production of fish meal has declined steadily (FAO, 2016) as soy-based and other vegetable-based protein sources replace fish meal in many feed formulations. However, this has increased the demand for soy, and thus the conversion of forests in places such as the Amazon for soy farms. In West Africa, a large percentage of small pelagic stocks are locally processed and often transported far inland to supply protein in the Sahel region where they are consumed as a cheap source of animal protein (see **Figure 9**). In this region, diversion of fish to become fishmeal is a threat to food security (Ayilu et al. 2016). As described in the aquaculture impacts section, introduction of non-native species for aquaculture is a concern due to the risks of incidental or intentional wild release where they can become invasive and affect native species and alter local aquatic ecosystems and wild fish productivity. There are also concerns of farm-raised animals transmitting diseases and parasites to wild stocks, or genetic degradation of wild stocks by farm-raised genetic strains due to inbreeding after accidental releases to the wild.

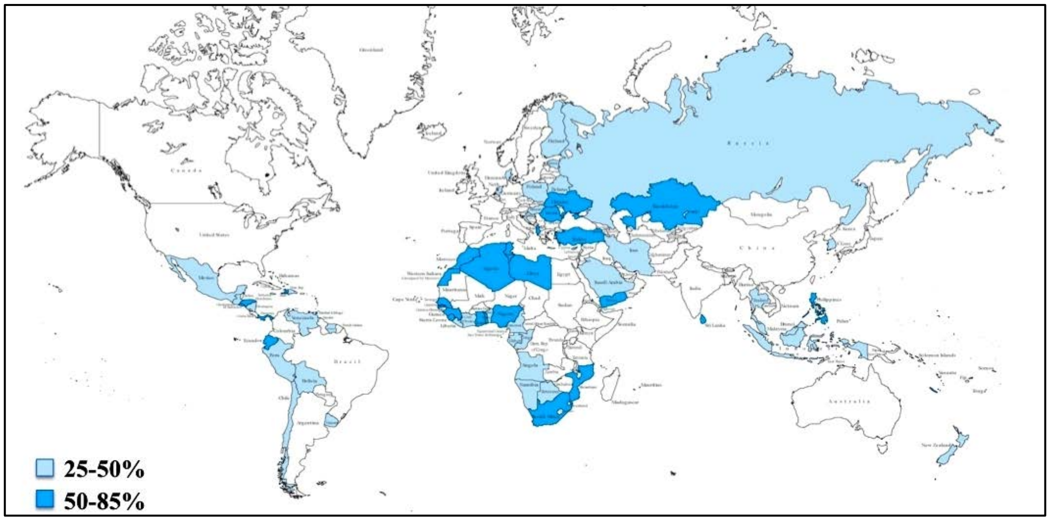


Figure 9. *Contribution of small pelagic forage fish to total fish food supply*
SOURCE: Taconand and Metian, 2009.

Aquaculture can also pose threats to critical habitats that serve as essential wild fish habitat in critical life stages. Large tracks of mangrove forests have been converted to shrimp ponds in Asia and Latin America even though they play an important role as nursery grounds for many commercially important species of fish. For example, a study in Mexico showed direct links of the extent of mangrove habitat to fish landings: each hectare of mangrove contributed $37,500 in fisheries landings (Aburto-Oropeza et al. 2008). In India, one hectare of mangroves has been shown to increase the marginal output of marine fisheries by 1.86 tons per year (Anneboina and Kumar 2017).

Although it has been recently pointed out by Henriksson et al., 2017 that some properly managed coastal ponds established in mangroves have been operated for many decades with minimal environmental impact, many shrimp ponds become unproductive after years of operation (Kauffman et al, 2009; Kauffman et al., 2017). When this happens, the areas are abandoned with damage to the naturally productive mangrove fisheries system. For example, a study in Thailand showed that mangrove destruction led to economic losses of $253 per hectare, which was much less than the short-term gains from aquaculture conversion. However, when discounted over time and factoring in timber values, intact mangroves showed ten times the discounted returns compared to shrimp farming (Barbier 2003).

Socio-economic interactions between wild-caught fishing and aquaculture also exist and must be taken into consideration. For example, the establishment of fish ponds in the Democratic Republic of Congo shifted the economic and power benefits from women to men. Traditionally, women would collect wild fish from the rivers and creeks and then sell them at local markets and use for household consumption. Once fish ponds were established with development assistance, men assumed control of the ponds where women were expected to work for free. This reduced women's access to incomes and nutritionally-rich foods. In Bangladesh, a USAID-funded project focused on helping women develop fish ponds. However, this empowerment of women and flow of economic benefits to them led to resentment and tension with men.

CLIMATE CHANGE IMPACTS ON FISHERIES AND AQUACULTURE

The Intergovernmental Panel on Climate Change states that climatic changes are impacting food security globally, with most prominent impacts on small-scale producers (Vermeulen, 2014). A global analysis of fisheries revenues suggests that developing countries with high fishing dependency will be most negatively affected by the impacts of climate change (Lam et al. 2016). Blasiak et al. (2017) assessed 147 countries on vulnerability of national economies to climate change impacts on fisheries using a vulnerability index and found that 87% of least developed countries are within the top half of that index, attributing this to lower levels of adaptive capacity in these countries. Changes in climate are anticipated to increase inland wild-caught freshwater fisheries' vulnerability due to changes in water quality by decreasing dissolved oxygen, changing water chemistry, and potentially increasing heavy metal concentrations (Chen et al. 2016). Therefore, it is especially important to assess, address, and adaptively manage climate risks when designing fisheries and aquaculture projects.

For a detailed description of how to assess and address climate-related risks, see the Climate Risk Screening and Management Tool. These tools guide project development to define the scope of the project, assess climate risks that could impact project activities, and assess adaptive capacity; assign risk ratings for each climate risk and adaptive capacity; explore potential opportunities that could arise from these risks; and describe management options that address positive and negative aspects of the climate risks.

Specific impacts of climate change on fisheries and aquaculture are briefly described in the table below with examples of specific socioeconomic and ecological impacts. (For more information on the impacts of climate change on fisheries and aquaculture see USAID's Climate Risk Screening and Management Tool – Environment and Biodiversity Annex, *Our Shared Seas – A 2017 Overview of Ocean Threats and Conservation Funding* and *Ocean Tipping Points Guide: Science for Managing a Changing Ocean.*)

TABLE 2: CLIMATE STRESSORS AND IMPACTS ON FISHERIES AND AQUACULTURE

CLIMATE STRESSORS	DIRECT AND INDIRECT IMPACTS ON FISHERIES AND AQUACULTURE
Ocean acidification due to increased dissolution of carbon into seawater	• Crustaceans and mollusks may have more difficulty forming their exoskeleton (i.e. exterior shell), especially for juvenile life stages. This may cause: o Increased mortality rates o Reduced reproductive success of bivalves • Acidic seawater impacts coral ability to deposit calcium carbonate and build its skeleton. In addition, it may affect ability of coral to grow through: o Increased reef erosion

TABLE 2: CLIMATE STRESSORS AND IMPACTS ON FISHERIES AND AQUACULTURE	
CLIMATE STRESSORS	DIRECT AND INDIRECT IMPACTS ON FISHERIES AND AQUACULTURE
	o Reduced structural integrity of reefs o Decreased ability to provide habitat for fisheries
Increasing sea surface and pond temperature due to increased absorbed heat from air	• Fish stock and prey species composition, distribution, and population changes due to fish migration to colder or warmer water can cause the following impacts: o Decreased catch rates for targeted species in the original location o A need for revised fishing regulations and management as fishers migrate with the fish o Increased potential for interaction between targeted and bycatch species o Changed location and period of spawning could affect fish stock growth and survival o Decreased recruitment of fish species o Additional challenges for fisheries management related to trans-boundary stocks, decreased accuracy of scientific advice based on historical data, and effectiveness of existing strategies • Changes in primary productivity can cause changes in fish yields • Environmental conditions may exceed species' biological requirements, resulting in decreased abundance • Increased incidence and spread of pathogens due to increased temperature and salinity. This may have the following impacts: o Decreased catch rates and fish quality o Increased risk of fish loss in aquaculture operations due to decreased dissolved oxygen and increased disease risks o Loss of coral reefs from bleaching o Increased vulnerability to disease o Reduced growth and reproduction o Decreased biodiversity and habitat for fish
Sea level rise due to melting glacial waters and expansion of	• Coastal erosion can cause indirect impacts: o Increased vulnerability of coastal infrastructure o Inland migration of coastal fisheries habitat

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CLIMATE STRESSORS	DIRECT AND INDIRECT IMPACTS ON FISHERIES AND AQUACULTURE
ocean waters due to increased temperatures	o Decreased coastal fisheries habitat such as mangrove forests and seagrass meadows o Decreased/loss of carbon sequestration by wetlands, seagrasses, and mangroves • Salt water intrusion into coastal aquifers can cause the following impacts: o Increased salinity, which may decrease aquaculture capabilities for freshwater operations o Reduced freshwater supplies at fish landing and processing sites
Changing frequency and intensity of storms	• Changing storm patterns increase vulnerability of social and natural systems: o Increased risk for fishers at sea o Increased risk of damage to aquaculture operations from more intense storms including potential for penned fish to escape o Increased vulnerability of coastal infrastructure
Changes in patterns and seasonality of precipitation	• Seasonal waterbodies could dry up, which can have the following impacts: o Decreased habitat for fisheries o Reduced availability of waterbodies for seasonal aquaculture • Increased intensity and amount of rainfall may cause: o Flooding o Pulse inputs of freshwater into nearshore marine systems, which may negatively impact juveniles of target fisheries species o Increased sedimentation

SECTOR PROJECT AND ACTIVITY DESIGN – SPECIFIC ENVIRONMENTAL GUIDANCE

Most USAID wild-capture fisheries projects and activities, especially those funded with biodiversity funding, are designed to improve sustainable fisheries management, livelihoods, and food security, and to minimize harm to the environment by improving and conserving biodiversity and their ecosystem services. Likewise, aquaculture projects and activities are designed with the intent of increasing food security and generating income for local smallholders. However, there may be situations where activities could have unintended adverse environmental and socio-economic impacts. USAID published a number of guidance documents, including a guide on Sustainable Fisheries and Responsible Aquaculture (2013), which provides detailed guidance for staff and partners on how to design fisheries and aquaculture projects. This section builds on that guidance document, focusing on the good management practices and design criteria that can help prevent damaging environmental impacts.

BEST PRACTICES APPLICABLE TO FISHERIES AND AQUACULTURE

Developing a fisheries or aquaculture development project is a stepwise process that begins with identifying the key issues— the socioeconomic and biophysical drivers that threaten sustainability—and thereafter setting the goal and developing a plan of action. The project objectives should be clear and accommodate short-term outputs as well as longer-term changes in social and environmental indicators, such as policy gaps, management capacity, food production, and fish populations. Monitoring, evaluation, and learning need to be designed into the project at the outset to track environmental outcomes and impacts. This should include conducting **baselines, environmental and socioeconomic assessments, and assessments of current and applied science** to create evidence-based analyses that help identify environmental changes, impacts, and mitigation strategies. The assessment should include the status of and gaps in policies, regulations, and management capacity, and extension services. Mapping is useful during the assessment phase because they can for example pinpoint areas suitable and unsuitable for aquaculture and establish geo-referenced points. It is important to validate local knowledge with scientific, evidence-based data and analysis discern the effects of fisheries and aquaculture from other environmental and human threats and stressors.

Participatory resource assessments, including community-based mapping and other tools can be used to identify critical habitats and fishing grounds, who is using fisheries and aquaculture-related resources, who benefits from resource exploitation, and who would be impacted by either fisheries management or aquaculture development. This is important from an environmental impact perspective because it identifies the pressures that different resource user groups have on the environment. It can also help identify shifts in environmental pressures, economic benefits, or power arrangements as a result of fisheries and aquaculture development.

Empower women and other marginalized groups to participate in the management of fisheries and aquaculture. In coastal fishing communities, there are clear roles for men, women, old, young, rich, and poor. Gender relationships are determined by social structures and shaped by social relations. Men and women have different perspectives, interests, needs, and priorities, which must be clearly understood before successfully engaging them in fisheries management. For example, there are instances where women fish traders have boycotted fish caught with small mesh nets and dynamite—in essence becoming advocates for conservation. However, when not engaged, women could unintentionally also support environmentally harmful fishing practices.

Factors that influence women and men's ability to engage in fisheries management

Women and men tend to do different work in the fisheries sector.

Women tend to have less access than men to formal decision-making authorities and are less involved in local decision-making structures.

Women and men have different access to and control over fisheries resources.

Women and men have different spheres of traditional knowledge and leadership.

Women and men have different domestic responsibilities, including financial expenditures.

Design approaches to **strengthen resilience of the ecosystem and reduce climate risks**. "No regrets" approaches—i.e., approaches that are beneficial even in the absence of climate change—make sense. These may include **large-scale landscape and seascape planning and zoning for specific uses and user groups**. It is important to see the full picture of resource use and user groups in an area to understand the cascading effects that aquaculture and fisheries development can have. Spatial planning and zoning can lessen conflicts over resource use and ensure that aquaculture operations and fisheries stay within the surrounding ecosystem's carrying capacity. Follow the **precautionary approach**. For example, if a stock status is unknown or if anecdotal evidence (e.g., local knowledge) suggest that the fisheries is fully exploited, then avoid supporting activities that increase effort. **Donor coordination can create synergies** at the same time as it can help avoid unintentional environmental impacts. For example, although well intended, a donor-funded project to replace fishing vessels after a tsunami or hurricane may contradict a different donor project working on reducing fishing effort.

FISHERIES

Unsustainable and improperly managed fishing can lead to unwanted environmental, economic, and social impacts. The first step towards preventing environmental and social impacts in fisheries is to **support sound fisheries management and good governance**. This means including environmental objectives (e.g., to prevent overexploitation and degradation of ecosystem health) into the broader capture fishery's vision or goal. Best management guidelines that support environmentally sound fisheries include:

- **Projects and activities should be designed to prevent or reduce overfishing for all fish populations.** Any project or activity that promotes increased fishing capacity and fishing effort should be avoided for stocks that are considered fully fished or overfished and for any populations without adequate management systems in place. **Understanding the current status of the fish stocks** is an important first step in fisheries project design. FAO and national bodies are tasked with conducting fish stock assessments. Stocks that have not been assessed are referred to as data-poor fisheries. Where stock status is unknown, the precautionary principle suggests that no capacity or effort increases should be contemplated (Garcia 1994; Costanza et al. 1998; Weiss, 2006).

- **Use co-management approaches and strengthen fishing associations. Inclusive, participatory processes** that engage fisheries stakeholders and fishing associations in management plans and best practices create local engagement and ownership. They allow local stakeholders to generate place-based fisheries management rules that aim to reduce, mitigate, or eliminate activities that degrade resources or ecosystem services, while promoting those that support natural processes and help "grow' fish populations. For large countries or small-scale stocks, it may make sense to decentralize the management to village, district, or regional level. Local fisheries management established without a strong constituency of fishers will likely face high levels of non-compliance, which in turn may have negative environmental impacts.

- **Move from open access to managed or restricted access systems and promote secure tenure and use rights.** Restricted access and use rights over fishing grounds and resources tend to provide long-term economic incentives for those in the fishery to engage in sustainable conservation practices, avoiding the tragedy of the commons. Output controls such as quotas can prevent stocks from becoming overfished and/or allow them to rebuild (Shepherd 1981; Castillo & Dresdner, 2013). However, managed access alone will not prevent overfishing or avoid ecosystem degradation unless effort and catch controls among those who have access are agreed upon and fully enforced. By managing access in combination with restricting effort among those with access rights, it is possible to keep fishing effort within the maximum biological yield, which allows the biological systems to be productive, healthy, and even grow over time. Design strategies to create managed-use rights that provide incentives for stewardship for improved fisheries management and that give fishers the legal authority to manage resources. Protected areas, sanctuaries, and no-take areas are forms of managed or restricted access that make sense for some fisheries. Although they displace rather than reduce effort, they are commonly established to enhance the natural productivity of fisheries and biological diversity by providing a safe haven for fish populations to feed, breed, and grow.

> The Government of The Gambia has granted exclusive use rights to the cockle and oyster fishery in the Tanbi Wetlands National Park to the TRY Oyster Women's Association. This is the first case of a women's group granted exclusive use rights to a fishery in Sub-Saharan Africa. Over 6,300 hectares of oysters and mangroves have been protected. Through concrete short-term value chain benefits and initiatives to strengthen social cohesion, solidarity, and conflict resolution, TRY has reduced fishing pressure and made visible progress towards medium– and long-term environmental benefits.

- **Fishing effort can be managed through input controls** such as closed seasons and areas, and banning certain highly efficient gear or sizes and lengths of nets. It is important to **consider environmental objectives when deciding between input and output controls.** Developed countries, including the United States, are putting more emphasis on quota- or catch-based management, which limits the number and size of fish harvested—i.e. the "output"—regardless of the inputs used. However, small-scale developing country fisheries still primarily rely on input controls, which control the effort used to harvest fish. Regardless of the type of control used, it is important to consider direct and indirect environmental impacts. For example, a focus on output controls may retain a fishery within the maximum sustainable yield, but it may also allow the use of gear that destroys habitats for other species. **Applying ecosystem-based fisheries management (EBM) strategies** will avoid this type of issues, because it focuses on conserving the underlying health and resilience of the fisheries ecosystem upon which productive and profitable fisheries depend. EBM considers the linkages between species and habitats and ensures that fisheries management minimizes impacts on habitats and the ecosystem.

- Enhance fish productivity and sustainability by **managing at the scale of the fish stock and conserving critical fish habitats.** Fish migrate across geographic boundaries and fisheries management will only be effective if it involves the full range of communities, regions, and/or countries that host the fish stock. If management does not cover the whole population, it may miss critical life cycle stages and habitats or it could displace fishing pressure from one area to another.

- **Design fisheries management and outreach/extension to fit local capacity as well as the complexity of the fishery.** For example, make sure that fishers use the most suitable types of gear for a fishery to avoid unnecessary bycatch. Build and leverage champions and constituency strategies that encourage stewardship, fair trade, and long-term productivity. Build the capacity of government institutions and universities to serve as extension services to disseminate best practices and strengthen fishing associations and co-management.

- **Projects should avoid promoting destructive gear** and should support policy and regulations that limit or ban their use. Projects can also promote and pilot test technological innovations that reduce environmental impact. Depending upon the nature and ecological complexity of the bottom, many experts believe that **lower impact gear** such as hand lines and fish pots are better because they exert less environmental damage on bottom substrates than trawl nets in sensitive areas (Kaiser and Spencer 1996; DeAlteris et al. 1999; Pitcher et al. 2016).

Common fisheries management measures implemented to **avoid capturing endangered, threatened, and protected species** are to ban some gear entirely or require devices that reduce incidence of bycatch. For example, the U.S. requires by law that turtle excluder devices be used on all trawlers targeting wild-caught shrimp products destined for U.S. import. Fisheries projects should avoid promoting gear that may increase the incidence of capture of ETP species and should consider supporting activities to reduce ETP bycatch (Lewison et al. 2004).

Adhere to relevant international agreements and commitments to environmental and social sustainability and good practices in fisheries project and activity design. One means to combat illegal fishing, in addition to strengthening fisheries management and enforcement, is to **support traceability strategies** for export commodities (including U.S. import requirements for catch documentation and traceability, CITES, etc.). The traceability of fish and other seafood products caught or traded by legal and illegal means remains a significant challenge, particularly in developing countries and for fish in domestic supply chains. Data on government landings reports and in vessel catch records exist but are generally not readily available, and illegal catch hotspots are poorly documented over time.

Avoid polluting the environment. There are a number of practical steps that people working onboard fishing vessels and in the post-harvest sector can do to prevent direct environmental impact. These include avoiding discharging polluted water, oil, and non-decomposable trash such as plastics into coastal and sensitive waters and excluding motorized vessels from areas that contain important shallow water habitats or small enclosed ecosystems.

Projects should take care not to support fisheries improvements that favor forced child labor and human trafficking. Where they do occur, projects should **consider the addition of components that contribute to the eradication of child labor and human trafficking** in the harvesting, processing, and other aspects of the supply chain. Activities can include traceability schemes, which help buyers avoid purchasing from supply chains known to engage in these practices, and promoting corporate social responsibility audits by large-scale buyers. In other instances, activities could involve community-based behavior change communication interventions to make the practices socially unacceptable.

AQUACULTURE

Uncontrolled aquaculture growth can lead to unwanted environmental, economic, and social impacts. To avoid adverse environmental impacts, aquaculture development endeavors must consider a number of issues such as governance, policy, and management frameworks; proper siting, permitting, and zoning; culture technologies and production oversight; extension capacity; processing; and transportation. Aquaculture-specific guidance includes:

Support strengthened governance and management systems for aquaculture, such as environmental rules and regulations and zoning/siting approval procedures for small, medium, and large production systems. Good governance, policies, and regulations, along with training, technical assistance, extension services, and monitoring at all levels of production are essential to minimize threats to the environment. This involves strengthening institutional extension capacity to **promote best aquaculture management practices** that address critical issues such as how to avoid transmission of disease and parasites to the wild population and how to reduce and mitigate water pollution.

Create synergies and collaboration between producers. Consider public policy and private sector agreements and commitments that can create opportunities and incentives for improved management. Spatial planning and zoning help mitigate environmental impacts by ensuring that producers are not too concentrated in one area, which in turn reduces the risks of disease.

Invest in technological innovation and transfer. Extension support and trainings in breeding and hatchery technology, disease control, feeds and nutrition, water supply, and wastewater treatment can help prevent environmental degradation. Provide incentives for sustainability. For example, low interest loans and tax exemptions to small-scale farmers can help farmers adopt technologies that increase productivity and reduce the pressure to clear new land.

Use an ecosystem approach to aquaculture management (EAAM) that integrates aquaculture ventures within the broader ecosystem to ensure that the activities do not threaten the sustained delivery of ecosystem services. Taking an EAAM approach includes carrying capacity modeling, watershed considerations (upstream and downstream), and the accumulative impacts of aquaculture—all important to taking a precautionary and adaptive approach.

Siting aquaculture operations in an appropriate manner is one of the best ways to ensure efficient farm operations, minimize environmental impacts, and reduce threats to biodiversity. Proper **siting of production systems** can help avoid loss of critical habitats such as mangroves, coral reefs, wetlands, lagoons, rivers inlets, bays, estuaries, swamps, marches, or high wildlife-use areas. Many factors must be considered when siting and building earthen pond systems, including soil type, grade, and elevation; distance from water sources; type of water source; and other physical factors. Farmers must be able to drain the ponds completely for harvesting and disinfecting (USAID 2013). Situate ponds away from tidal areas subject to flooding to avoid the spread of disease and contamination of freshwater.

General rules of thumb for siting aquaculture operations include: 1) maintaining adequate distance from other aquaculture enterprises, natural spawning runs, restricted areas, and sensitive ecosystems; 2) choosing sites with adequate wave, current, and tidal patterns; 3) avoiding sites that are close to polluting industries; 4) avoiding sites that are near wild stock populations; and 5) avoiding lakes and ponds that are sources of drinking water. Incorporate other aquaculture design considerations such as upstream and downstream water flows. For example, construct wetlands to treat the settling pond water from freshwater ponds before it is released downstream. Promote closed systems or terrestrial ponds with safeguards to **reduce escapees, diseases, parasites, and pollution**. Net pens should be sited in highly flushed, deep-water sites with no tidal reversals.

Promote low-impact species (low on the food chain) and use non-native species only where escape is impossible or where survival and reproduction under local conditions are impossible. Non-native species such as tilapia can be cultured in places where it has been cultured for a long time and is already well established. **Use best management practices (BMPs) in monitoring and controlling ponds.** Best management practices include using aquaculture feed that results in efficient feed conversion rates (FCRs) and low waste (e.g., use appropriate feed management and distribute feed evenly). Use approved drugs or pesticides only during disease outbreak only if recommended. Limit the use of fertilizer and monitor and control effluents before discharging to meet water quality standards for turbidity, suspended solids, pH, dissolved oxygen, etc. It is also important to collect and safely dispose of unmarketable fish, blood, and guts. Avoid discharges near or upstream of recreational areas, marine parks, fishing grounds, shellfish beds used for commercial or recreational harvest, or other sensitive areas.

Consider polyculture and integrated multi-trophic aquaculture (IMTA). Rice-fish polycultures have been shown to reduce the need for both pesticides and soil nutrients. The fish will consume algae and weeds, fertilize the water, and improve soil texture. Aquaculture in irrigation channels can potentially control algae and weeds if well managed.

Avoid culture, transport, and trade of live ornamentals. Ornamental fish for the aquarium trade are frequently captured illegally, using destructive fishing methods such as cyanide. Aquaculture of ornamentals is not advisable for the following reasons: 1) collecting wild seedlings will reduce the wild population; 2) without adequate traceability protocols, it is difficult to discern and certify the ornamentals that have been cultured sustainably and distinguish cultured from wild-caught specimens;

and 3) the transport and escape of wild species from the ornamental trade have caused serious harm in destination countries.

It is critical to **apply biosecurity measures** to prevent diseases from occurring and spreading. This includes controlling inputs (eggs, larvae, juveniles), supplies (food, veterinary products), water quality, and farm employee hygiene. However, an emerging issue is implementing biosecurity measures during transportation. For example, it is important to disinfect vehicles and maintain good hygiene during transport to avoid spreading of disease between farms. Biosecurity measures are also critical during the importation and regional transport of brood stock to avoid the spread of disease as well as aquatic invasive species. Biosecurity measures are also important for disease prevention and to avoid illegal imports of species and strains not duly approved.

POST-HARVEST HANDLING AND PROCESSING

There are environmental risks associated with post-harvest handling and processing of cultured and wild-caught fish. Post-harvest activities should be coupled with fisheries and aquaculture management that aims to achieve sustainable harvesting, prevent overfishing, or focus on fish varieties that are already sustainably harvested. Similarly, the post-harvest activities should be coupled with policy and management activities that promote sound permitting and licensing of processing facilities. Some best practices to avoid environmental impacts in post-harvest handling and processing include:

Invest in environmentally sound processing, packaging, and transportation methods. Develop best practice processing compacts that explain handling and food safety, including the use of good practices in disposal of fish processing waste and discarded fish guts (also called gurry). Use fuel-efficient technologies to avoid contributing to deforestation and overuse of fuelwood. Choose technologies that minimize smoke-related safety and health risks. Evaluate the sources for procuring construction materials to avoid adverse local impact. For post-harvest processing of wild-caught fish, it is important to couple efforts to increase the value of fish products with measures to manage fishing effort. Otherwise it is possible that the increased value will promote overfishing. **Improve landing sites and processing facilities** to limit the effluents and solid waste that may produce adverse effects on coastal and aquatic habitats. When rehabilitating landing and processing sites, minimize the impact on sensitive ecosystems and avoid contaminating groundwater and surface water. Avoid standing water, which attracts mosquitoes and other disease vectors. **Strengthen the role of women in the fisheries value chain** through management training and support for women fish processing associations. This is important, because excluding women in fisheries management and extension can result in poor processing practices and weaker fisheries management. **Avoid processing wild-caught fish for fish meal** because it may decrease the fish available locally for protein, disrupt livelihoods, and drive the demand and price of fish, spurring additional pressure on exploitation.

MITIGATION OF IMPACTS AND MONITORING

The previous sections have described how fisheries and aquaculture activities may directly and indirectly affect the aquatic resources and ecosystems that they depend on. The document has also provided best practice guidance about how to avoid negative environmental impacts. This section will provide guidance on how to monitor and mitigate negative environmental impacts.

Monitoring, evaluation, and learning are crucial for providing feedback about what works, does not work, and why—allowing projects to adapt and adjust implementation. To fully understand the potential impacts, it is critical to hypothesize how fisheries and aquaculture activities will interact with the environment and socioeconomic systems and determine what the positive and negative impacts will be. Then, if an action does not have the intended effect, project managers should determine if the problem is due to poor implementation or if the theory behind the implementation strategy is flawed.

To measure outputs, outcomes, and impacts, fisheries and aquaculture projects need to establish a clear understanding of the key issues and the relationships between the activity objectives, the environment, and socioeconomic systems; a clear theory of change, which is required for all USAID activities; and baselines, which will be the starting point for routine monitoring. Key questions are "What is the system or context in which the activity will be implemented?", "What is the theory of change for the activity?", and "What needs to be monitored?"

A series of tools or How-To-Guides, created for use in USAID biodiversity programming but applicable to many fields and endorsed by PPL, are available to USAID staff and implementers to help with each of these three questions.

1. The How-To-Guide on "Developing Situation Models in USAID Biodiversity Programming" allows an activity to map out the problem context to be addressed. (http://pdf.usaid.gov/pdf_docs/PA00M8MV.pdf).

2. The second How-To Guide on "Using Results Chains to Depict Theories of Change" builds off the situation model guide to help design teams develop results chains that clearly state the expected results and assumptions behind the proposed strategic approaches that make up the program's theory of change. (http://pdf.usaid.gov/pdf_docs/PA00M8MW.pdf)

3. The third How-To Guide on "Defining Outcomes and Indicators for Monitoring, Evaluation, and Learning" uses the results chains developed in the second guide and provides help identifying key results for developing outcome statements and performance indicators. (https://usaidlearninglab.org/sites/default/files/resource/files/biodiversity_howtoguide3_508.pdf

Fisheries and aquaculture projects will likely have a mix of indicators measuring biophysical conditions, socio-economic benefits, governance capacity, and management frameworks. Recommended monitoring and mitigation measures that can be taken to prevent the categories of environmental impacts identified above (in Section III) are summarized in the table entitled "Mitigation and Monitoring of Environmental and Socio-economic Impacts in Project and Activity Implementation."

TABLE 3. MITIGATION AND MONITORING OF ENVIRONMENTAL AND SOCIO-ECONOMIC IMPACTS IN PROJECT AND ACTIVITY IMPLEMENTATION		
POTENTIAL ADVERSE ENVIRONMENTAL IMPACTS	INDICATORS	MITIGATION MEASURES
WILD CAUGHT FISHERIES		
Impacts related to overfishing - Loss of species diversity, abundance, and biomass - Reduction in natural productivity and resilience - Changes in trophic structure and food web cascades	• Percentage of stock overfished • Degree of overfishing • Stock declining, stable, or rebuilding • Landings level • Excess capacity • Governance capacity and responsiveness • Season length • Level of subsidies • Data availability • Changes in net income • Local and export market prices	• Strengthen fisheries management and governance including co-management and use rights • Enhance training in fisheries best practices • Develop managed access and move away from open access • Develop systems for action and participatory research • Ensure that monitoring results are factored into revisions of fisheries management plans • Enhance record-keeping (e.g. using tablets for data collection) • Control illegal fishing in small-scale and industrial fisheries • Set minimum size limit for harvested fish • Select appropriate fishing gear based on target species • Select fishing nets with the appropriate mesh size • Close seasons during critical stages in the fish life cycles to increase natural productivity • Improve boat and fisher registration and licensing programs • Establish reserves/permanent closed areas or temporary area closures during critical life stages (spawning aggregations) • Promote aquaculture of species lower on the food chain to reduce dependence on wild-caught fish meal

TABLE 3. MITIGATION AND MONITORING OF ENVIRONMENTAL AND SOCIO-ECONOMIC IMPACTS IN PROJECT AND ACTIVITY IMPLEMENTATION		
POTENTIAL ADVERSE ENVIRONMENTAL IMPACTS	INDICATORS	MITIGATION MEASURES
Impacts related to fuel consumption - Emission of CO_2	• Fuel intensity per gear type • Number of fishing vessels with motors • Average number of hours that vessel engines are used per week	• Develop fuel efficiency standards • Cap the number of boats allowed in a geographical area • Control illegal fishing • Implement climate change mitigation measures, such as emissions reductions, carbon sequestration, and policy actions for mitigation
Impacts of the capture of endangered, threatened, and protected (ETP) species - Decrease in the populations of species such as turtles and dolphins	• Number of vessels using turtle-excluding devises • Number of ETP species caught as bycatch • Population sizes of ETP species	• Use bycatch reduction devices to allow large animals and ETP species to escape from nets • Ban small mesh nets and other gears that are prone to catching ETP species • Implement information, education, and communications campaigns to raise awareness of the importance of ETP species
Impacts related to destructive fishing practices - Decrease in non-targeted fish population and juvenile fish stocks - Decrease in sustainability and profitability - Degradation of coral reefs, seagrasses, and other aquatic	• Number of vessels/fishers using destructive gear • Number of policies/regulations/management actions implemented to reduce destructive practices • Illegal, unregulated, or unreported landings	• Use appropriate gear type for the different habitats and species to avoid harming the environment and its productivity • Promote the prohibition of destructive practices • Use mesh sizes that allow small and juvenile fish to escape • Use a square mesh or a mesh with square windows instead of a diamond-shaped mesh (diamond-shaped meshes constrict during towing) • Educate fishers about the long-term environmental and economic damage to ecosystems from using cyanide or dynamite

TABLE 3. MITIGATION AND MONITORING OF ENVIRONMENTAL AND SOCIO-ECONOMIC IMPACTS IN PROJECT AND ACTIVITY IMPLEMENTATION		
POTENTIAL ADVERSE ENVIRONMENTAL IMPACTS	INDICATORS	MITIGATION MEASURES
habitats (from bottom trawling) - Fish kills and habitat degradation/poisoning (from dynamite and cyanide fishing)	• Enforcement capability • Governance responsiveness • Management jurisdiction	• Implement bans on destructive gear and species that are in danger of commercial extirpation or with very low abundance • Engage with the private sector to develop fisheries improvement and certification initiatives.
Impacts related to loss of ecosystem services - Reduction of anadromous fisheries, leading to upstream impacts and reduced population sustainability - Reduction of seabed ecosystems, leading to reductions in demersal fisheries - Increases in bycatch and reduction in ecosystem integrity - Lost nets (ghost fishing), depleting resources and damaging non-target species - Plastic pollution	• Ecosystem performance index • Status of critical habitats (coral reefs, mangroves, submerged aquatic vegetation, etc.) • Proportion of critical habitats under protection	• Protect critical habitats important in critical life stages (breeding areas or nursery areas such as mangrove forests, coral reefs, or submerged aquatic vegetation • Develop plans for rehabilitating damaged ecosystems (e.g., reforestation) • Improve integrated planning • Include climate information in land-use and project planning • Educate and build awareness about ecosystem services • Register nets and gear to discourage indiscriminate discarding • Promote recycling of plastic and old nets; create financial incentives for recycling and/or proper waste management

TABLE 3. MITIGATION AND MONITORING OF ENVIRONMENTAL AND SOCIO-ECONOMIC IMPACTS IN PROJECT AND ACTIVITY IMPLEMENTATION		
POTENTIAL ADVERSE ENVIRONMENTAL IMPACTS	INDICATORS	MITIGATION MEASURES
Socio-economic impacts related to fisheries management interventions - Increased incidence of poverty and food insecurity among poor and vulnerable households - Increased gender inequity - Elite capture of benefits, which may lead to conflicts from disproportionate capture of fisheries benefits - Forced child labor, human trafficking - Poor labor conditions and lack of fair pay	• Incidence of food insecurity • Gender equity • Governance quality • Governance responsiveness • Stakeholder engagement • Leadership capacity and commitment • Access to financial services for fishers • Number of small-scale fishers with secure access to fishing grounds/resources (tenure, zoning for small-scale, etc.) • Access to extension services on best practices • Number of nutrition-sensitive fishing and processing policies, regulations, actions that	• Support the establishment of a community counsel to ensure greater voice is given to a diverse range of stakeholders in the design and implementation of the project. • Promote the establishment of exclusive use zones for small-scale fishers. • Develop interdisciplinary partnerships that include fisheries, aquaculture, ecosystem managers, nutritionists, economists, and policy makers to address nutrition issues and food insecurity • Mainstream gender throughout the fisheries value chain • Develop governance capacity to reduce elite capture • Increase stakeholder engagement and transparency • Strengthen monitoring, control, and surveillance (MCS) • Develop fisheries management leadership • Engage private sector in developing incentives to improve labor conditions

TABLE 3. MITIGATION AND MONITORING OF ENVIRONMENTAL AND SOCIO-ECONOMIC IMPACTS IN PROJECT AND ACTIVITY IMPLEMENTATION		
POTENTIAL ADVERSE ENVIRONMENTAL IMPACTS	INDICATORS	MITIGATION MEASURES
	ensure availability of fish for local consumption	
AQUACULTURE SITE SELECTION AND CONSTRUCTION		
Habitat loss and degradation - Habitat clearing for the construction of ponds or other forms of aquaculture (e.g. seaweed) - Erosion from aquaculture construction - Seepage into ground and surface waters	• Environmental performance index • Status of critical habitats (coral reefs, mangroves, submerged aquatic vegetation, etc.) • Proportion of critical habitats under protection • Hectares of healthy mangrove forest/wetland/coral reef area • Number of policies/regulations/management actions implemented for proper siting	**Site selection** • Avoid siting ponds in mangrove forests. If mangroves are cut, promote the restoration of mangrove forests. • Use already cleared land whenever possible; reuse existing ponds before creating new ones to minimize disturbance of soil and vegetation • Site ponds on the landward side of mangrove forests; leave the seaward side undisturbed and ensure adequate flow of freshwater for the mangroves. **Construction of aquaculture operations** • Consider floating and submerged cages rather than earthen ponds. Use off-bottom culture techniques for seaweed • Build smaller ponds that are easier to manage and may have fewer environmental impacts • Build ponds on soils with adequate clay content • Space ponds well apart • Support the establishment or strengthening of policies and management that promote the proper siting of aquaculture ponds, the appropriate selection of species, and proper water management to reduce cumulative impacts on the environment.

TABLE 3. MITIGATION AND MONITORING OF ENVIRONMENTAL AND SOCIO-ECONOMIC IMPACTS IN PROJECT AND ACTIVITY IMPLEMENTATION		
POTENTIAL ADVERSE ENVIRONMENTAL IMPACTS	INDICATORS	MITIGATION MEASURES
Rerouting of water flows through pond enclosures - Disease outbreaks - Changes in hydrologic patterns	• Water flow • Water quality (input and output)	• Evaluate how much water can be taken from a given water body or how much effluent it can receive without important alterations to its ecological equilibrium. • Construct adequate water inlet and outlet systems, taking into account water flow and water quality impacts • Use lower stocking densities and less intensive production systems • Establish or strengthen management of water and flows at the larger watershed level
AQUACULTURE OPERATIONS		
Water contamination and sedimentation - Solid waste pollution - Sediment discharge - Effluent discharges into the ecosystem and open waters. This may include aquaculture feed, waste, and chemicals used for pesticide control, disinfection, and growth promotion	• Sediment discharge • Water quality • Pollution shocks and accidents • Level of chronic pollution • Pollutant concentrations in the environment and inside ponds: loadings of nitrogen, phosphorous, organic matter, suspended solids, and 5-day biochemical oxygen demand	• Develop national guidelines for the use of chemicals, pesticides, feed, and waste • Reduce, recycle, and buy-back plastic waste (including lines, containers, netting, etc.) used in aquaculture **Control effluent discharge** • Implement measures to control site drainage, surface runoff, and sewage discharge during construction and operation • Promote closed culture systems and the establishment of policies that prohibit cage or net culture in open water • Build ponds on soils with adequate clay content to avoid seepage into groundwater and surface water • Use settling ponds or other control structures • Maintain vegetated buffer zones

TABLE 3. MITIGATION AND MONITORING OF ENVIRONMENTAL AND SOCIO-ECONOMIC IMPACTS IN PROJECT AND ACTIVITY IMPLEMENTATION		
POTENTIAL ADVERSE ENVIRONMENTAL IMPACTS	INDICATORS	MITIGATION MEASURES
		• Do not discharge nutrient-enriched water into freshwater bodies • Use polyculture (e.g., raising several species, including at least one herbivorous species) to consume excess nutrients. • Implement integrated multitrophic aquaculture to recuperate carbon, nitrogen, and phosphorous supplied to the system and to diminish the environmental impacts caused by the effluents • Promote the culture of filter feeders—organisms that strain their food out of the water—to reduce waste and improve water quality by consuming plankton and preventing eutrophication • Consider growing mollusks, macro algae, and microalgae by themselves or in conjunction with other species to reduce nutrient loading and eutrophication **Reduce overcrowding and overfeeding, which create excess effluents** • Use lower stocking densities • Use high-quality feed and increase the frequency of feedings to diminish the pollution potential of effluents • Feed the right amounts at the right times; use feed pellets designed to float longer in the water column. **Reduce adverse impacts from the use of chemicals** • Use IPM or polyculture to control weeds. • Construct deeper ponds. • Consider use of less-toxic alternatives to hazardous products.

TABLE 3. MITIGATION AND MONITORING OF ENVIRONMENTAL AND SOCIO-ECONOMIC IMPACTS IN PROJECT AND ACTIVITY IMPLEMENTATION		
POTENTIAL ADVERSE ENVIRONMENTAL IMPACTS	INDICATORS	MITIGATION MEASURES
		• Designate areas for storage and refueling. Apply chemicals with proper containment away from watercourses or wetlands. • Prepare an Emergency Spill Response Plan. • Contain spills and treat contaminated soil and water as required. **Prevent spreading disease through water contamination** • Filter or ozonate the effluent from pond and recirculating tank systems • Promptly remove diseased and dying fish • During disease outbreaks, retain aquaculture effluent to prevent disease from spreading to wild populations • Promote the establishment of policies and regulations that prohibit fish cages to prevent the buildup of fish wastes and sediment • Avoid frequent draining of shrimp ponds in order to allow microbial processes and deposition to remove nutrients and organic matter from within, which will also conserve fresh water **Control effluents** • Use aeration and water circulation to break down organic matter and minimize anaerobic sediment accumulation at the bottom of shrimp ponds. Aeration may also remove ammonia. • Use settling ponds to treat suspended solids • Always settle effluents released at the time of harvest • Consider use of less toxic alternatives to hazardous products

TABLE 3. MITIGATION AND MONITORING OF ENVIRONMENTAL AND SOCIO-ECONOMIC IMPACTS IN PROJECT AND ACTIVITY IMPLEMENTATION		
POTENTIAL ADVERSE ENVIRONMENTAL IMPACTS	INDICATORS	MITIGATION MEASURES
		• Improve training of technicians
Impacts on the aquaculture pond and immediate area - Salinization/Acidification of soils - Erosion - Impacts on pond floor	• Degree of soil salinity/acidity	• Implement sustainable aquaculture technologies that limit the salinization and acidification of soils, allowing aquaculture operations to remain productive over time. • Use off-bottom systems such as rafts and lines for mollusk culture • Use settling ponds or other control structures • Plan for seasonal weather patterns and other constraints that influence erosion. • Pre-determine shutdown criteria for bad weather conditions. • Maintain a vegetated buffer zone
Trapping and collection of wild eggs, larvae, juveniles, and adults for aquaculture production—which may lead to overharvesting	• Prevalence of use of wild organisms in aquaculture	• Use hatcheries to provide eggs, larvae, etc. for aquaculture operations
Introduction of non-endemic and invasive species along with pathogens, predators, parasites, and diseases into the ecosystem, with adverse effects on fisheries	• Prevalence of non-endemic and invasive species • Prevalence of pathogens • Prevalence of predators • Prevalence of parasites • Prevalence of disease	**Species selection** • Select native rather than exotic species. • Consider using some species (e.g., tilapia) that are cultivated worldwide and may be appropriate even though they are not native to a place. • Gather information about the biology and ecology of the organism to be farmed (life cycle, nutritional requirements, tolerance to environmental change, etc.) to ensure that the species will survive in the planned aquaculture environment.

TABLE 3. MITIGATION AND MONITORING OF ENVIRONMENTAL AND SOCIO-ECONOMIC IMPACTS IN PROJECT AND ACTIVITY IMPLEMENTATION		
POTENTIAL ADVERSE ENVIRONMENTAL IMPACTS	INDICATORS	MITIGATION MEASURES
	• Proportion of sick animals; number of diseased animals/total animals/incidences of disease outbreaks	**Disease prevention** • Stock certified pathogen-free fish • Use lower stocking densities • Vaccinate fish • Apply integrated pest management • Filter or ozonate the effluent from pond and recirculating tank systems • Promptly remove diseased and dying fish • During disease outbreaks, retain aquaculture effluent to prevent disease from spreading to wild populations • Consider treating the influent water supply (for example, with chlorine) to eliminate pathogens and associated use of chemicals • Set up multiple safeguards to reduce escapes
POST-HARVEST HANDLING AND PROCESSING OF WILD CAUGHT FISHERIES AND AQUACULTURE		
Post-harvest handling - Landing site infrastructure/activities that affect sensitive coastal habitats and human health	• Technology adoption • Road and infrastructure quality • Landing site sanitation and hygiene • Landing site management capacity	Follow USAID small-scale construction guidelines: (http://www.usaidgems.org/sectorGuidelines.htm) (http://www.usaidgems.org/Documents/VisualFieldGuides/ENCAP_VslFldGuide--Construction_22Dec2011.pdf

TABLE 3. MITIGATION AND MONITORING OF ENVIRONMENTAL AND SOCIO-ECONOMIC IMPACTS IN PROJECT AND ACTIVITY IMPLEMENTATION		
POTENTIAL ADVERSE ENVIRONMENTAL IMPACTS	INDICATORS	MITIGATION MEASURES
	• Landing site security • Reliability of utilities and electricity • Access to ice and refrigeration	
Post-harvest processing - Disturbances to existing landscapes, habitats, water resources, and sensitive ecosystems due to facility renovation and construction - Increased fishing pressure and overfishing due to increased profitability from post-harvest processing. - Adverse effects on the receiving coastal and marine environment from fish processing effluents and solid waste - Disturbances in habitat and local hydrology from land use changes arising from construction	• Number of buyers • Degree of vertical integration • Technology adoption • Access to extension service • Post-harvest site safety • Post-harvest site sanitation and hygiene • Post-harvest management capacity • Reliability of utilities and electricity • Access to ice and refrigeration • Capacity among post-harvest processors	• Establish a technical monitoring construction committee to monitor construction and evaluate its compliance, ensuring that building permits and licenses are obtained as necessary • Establish or strengthen fishing association that will be responsible for maintaining landing sites and processing facilities • Do not allow activities within 30 meters of a permanent or seasonal stream or water body • Follow proper health and sanitation procedures, including in the disposal of fish processing waste and fish gurry • Develop codes of good practice that include agreement to not purchase or process juvenile fish or illegally caught fish • Ensure that construction materials and wood for smoke drying are sustainably and responsibly sourced • Support the establishment of policies that limit the number and capacity of processing facilities based upon the sustainability of the fish populations and the type (small-scale or large-scale) of processing facilities based upon equity for small-scale fishers and processors. • Follow USAID food processing guidance:

TABLE 3. MITIGATION AND MONITORING OF ENVIRONMENTAL AND SOCIO-ECONOMIC IMPACTS IN PROJECT AND ACTIVITY IMPLEMENTATION		
POTENTIAL ADVERSE ENVIRONMENTAL IMPACTS	INDICATORS	MITIGATION MEASURES
- Breeding habitat for mosquitoes and other disease vectors from standing water - Adverse local impacts from local procurement of construction materials (timber, fill, sand, and gravel, etc.) - Safety and health risks for fish processors who smoke dry fish. - Odor pollution from fish processing - Deforestation and over use due to smoke drying with wood - Lack of adequate management of forests where wood is sourced - Poor processing practices and weaker fisheries management due to exclusion of women in	• Ratio of resident and non-resident processors • Worker experience • Loss/degradation of forest area	http://www.usaidgems.org/Documents/MSEs/USAID_MSE_Sector_Guideline_Food_Processing_2013.pdf • Follow USAID small-scale construction guidelines: (http://www.usaidgems.org/sectorGuidelines.htm) (http://www.usaidgems.org/Documents/VisualFieldGuides/ENCAP_VslFldGuide--Construction_22Dec2011.pdf

TABLE 3. MITIGATION AND MONITORING OF ENVIRONMENTAL AND SOCIO-ECONOMIC IMPACTS IN PROJECT AND ACTIVITY IMPLEMENTATION		
POTENTIAL ADVERSE ENVIRONMENTAL IMPACTS	INDICATORS	MITIGATION MEASURES
fisheries management and extension - Poor labor conditions and fair pay		
Decrease in fish available locally for protein - Disruption to livelihoods - Increase in the demand and price of fish - Over exploitation (from processing wild-caught fish for fish meal)	• Prevalence of processed capture fish in fish meal/feed • Number of nutrition-sensitive fishing and processing policies, regulations, and actions that ensure availability of fish for local consumption	• Promote the establishment of policies and regulations that reduce and eliminate the use of wild-caught fish for fish meal – Promote policies that favor processing facilities that serve export markets rather than creating fish meal – Promote the use of innovative meals made from terrestrial animal byproducts, insects, plant oilseeds, and grain legumes (from yeast or from cereal byproducts) – Consider culturing herbivorous fish and filter-feeders that do not require feed inputs – Promote investment in less intensive and domestically oriented aquaculture of affordable and nutritious species – Farm species lower in the food chain to reduce dependence on wild-caught fish meal (Golden et al. 2016) • Allocate land and water resource rights to small-scale aquaculture

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RESOURCES

Aquaculture Certification Council https://bapcertification.org/

The Meloy Fund: A Fund for Sustainable Small-scale Fisheries in Southeast Asia https://www.thegef.org/project/ngi-meloy-fund-fund-sustainable-small-scale-fisheries-southeast-asia

USAID Feed the Future Innovation Lab for Collaborative Research on Aquaculture and Fisheries Projects https://aquafishcrsp.oregonstate.edu/projects

USAID's Biodiversity Policy. https://www.usaid.gov/biodiversity/policy

USAID Biodiversity Conservation Gateway https://rmportal.net/biodiversityconservation-gateway This resource is a clearinghouse for all documents produced by all USAID projects. This site can be used to search by project name for any past or present USAID project.

USAID Biodiversity Conservation Gateway. Interactive Inventory of International Capacity Building Initiatives for Fisheries. https://rmportal.net/biodiversityconservation-gateway/legality-sustainability/fisheries-development/project-search

USAID Biodiversity How-to Guide 1 - Developing Situation Models in USAID Biodiversity Programming, August 2016
http://pdf.usaid.gov/pdf_docs/PA00M8MV.pdf

USAID Biodiversity How-to Guide 2 - Using Results Chains to Depict Theories of Change in USAID Biodiversity Programming, August 2016
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USAID Biodiversity How-to Guide 3 - Defining Outcomes & Indicators for Monitoring, Evaluation, and Learning in USAID Biodiversity Programming, August 2016
https://usaidlearninglab.org/sites/default/files/resource/files/biodiversity_howtoguide3_508.pdf

USAID Climate Risk Screening and Management Tool
https://www.climatelinks.org/resources/climate-risk-screening-management-tool

USAID Climate Risk Screening and Management Tool – Environment and Biodiversity Annex
https://www.climatelinks.org/sites/default/files/2017-05-24%20USAID%20CRM%20Tool%20Environment%20and%20Biodiversity%20Annex.pdf

USAID Sustainable Fisheries and Responsible Aquaculture: A guide for USAID Staff and Partners.
http://www.crc.uri.edu/download/FishAquaGuide14Jun13Final.pdf

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ANNEX I: EXAMPLES OF RECENT AND ONGOING USAID FISHERIES AND AQUACULTURE PROJECTS

TABLE A I. EXAMPLES OF RECENT AND ONGOING FISHERIES PROJECTS

COUNTRY	PROJECT NAME	FOCUS AREA(S)	FUNDING TYPE	TIME FRAME
Global	Seafood Alliance for Legality and Traceability (SALT)	Global alliance for knowledge exchange and action Promote legal and sustainable fisheries Improve transparency of seafood supply chains.	Biodiversity	2017-2020
AFRICA				
Malawi	Fisheries Integration of Society and Habitats (FISH)	Biodiversity conservation for human wellbeing Improved management of freshwater lakes and fisheries Food security and livelihoods Resilience to climate change Sustainable fisheries co-management	Biodiversity, Global Climate Change Adaptation (Malawi Economic Growth office)	2014 - 2019
Ghana	Ghana Sustainable Fisheries Management Project (SFMP)	Food security, nutrition and livelihoods Coastal fisheries governance and management	Biodiversity Feed the Future (Ghana Economic Growth office)	2014-2019

TABLE A 1. EXAMPLES OF RECENT AND ONGOING FISHERIES PROJECTS				
COUNTRY	PROJECT NAME	FOCUS AREA(S)	FUNDING TYPE	TIME FRAME
		Rebuild target fish stocks (esp. small-scale pelagic fisheries)		
Senegal	Collaborative Management for a Sustainable Fisheries Future in Senegal (COMFISH Plus)	Food security and sustainable livelihoods Improve governance and co-management of fisheries Reduce illegal fishing Gender empowerment	Biodiversity, Feed the Future (Senegal Economic Growth office)	2016-2018
Regional **West Africa**	West Africa Biodiversity and Integrated Climate Change (WA-BICC)	Capacity building for law enforcement officials Sustainable livelihoods Coastal resilience	Biodiversity, Global Climate Change, Sustainable Landscapes (West Africa Economic Growth office)	2015 - 2020
Somalia	Growth, Enterprise, Employment and Livelihoods (GEEL)	Economic growth and jobs Capacity building for sustainable fisheries management Combat illegal fishing Reduce reliance on inputs	Biodiversity Economic Support Funds (USAID/East Africa, Somalia Unit)	2015 - 2020
LATIN AMERICA AND CARIBBEAN (LAC)				
Regional	Central America Regional Biodiversity Coastal Project	Improve management of biodiversity for secure	Biodiversity	2018 – 2023

TABLE A 1. EXAMPLES OF RECENT AND ONGOING FISHERIES PROJECTS				
COUNTRY	PROJECT NAME	FOCUS AREA(S)	FUNDING TYPE	TIME FRAME
		livelihoods and national security Increase resilience to climate change Sustainable natural resource use		
Regional	Caribbean Marine Biodiversity Program (CMBP)	Marine Protected Area (MPA) management and governance Fisheries governance and management Reduce threats to biodiversity to maintain ecosystem services and improve human well-being	Biodiversity	2014 - 2019
ASIA				
Indonesia	Sustainable Ecosystems Achieved (SEA)	Improve livelihoods, food security and nutrition Strengthen fisheries and coastal governance Maintain productivity of fisheries Marine Protected area management Combat illegal fishing	Biodiversity Feed the Future	2015-2020
Indonesia	Assistance to National IUU Task Force	Combat illegal and unreported fishing Strengthen national capacity and security	USAID and GOI partnership with INTERPOL	2016 - 2019?

TABLE A 1. EXAMPLES OF RECENT AND ONGOING FISHERIES PROJECTS				
COUNTRY	PROJECT NAME	FOCUS AREA(S)	FUNDING TYPE	TIME FRAME
Philippines	Ecosystems Improved for Sustainable Fisheries (ECOFISH)	Food security, nutrition and livelihoods Coastal fisheries and management Improve Governance and access Ecosystem-based management Improve productivity and profitability of fisheries	Biodiversity (Philippines Economic Growth office)	2012-2017
Philippines	Fish Right	Sustainable use/resilience of critical coastal and marine resources Sustainable fisheries management	Biodiversity	2018-2023
Regional	Oceans and Fisheries Partnership (OCEANS)	Sustainable fisheries management Catch documentation and traceability Reduce illegal fishing and trade in illegally caught products Industry and Market Incentives, Governance and Management, Fostering Constituencies and Political Will, Transparency	Biodiversity (Regional Development Mission for Asia [RDMA])	2015 - 2020
Bangladesh	Enhanced Coastal Fisheries (ECOFISH[BD])	Community-based wild fisheries management Food security and nutrition	Biodiversity	2014-2019

TABLE A 1. EXAMPLES OF RECENT AND ONGOING FISHERIES PROJECTS				
COUNTRY	PROJECT NAME	FOCUS AREA(S)	FUNDING TYPE	TIME FRAME
		Fish sanctuaries Livelihood development		

TABLE A 2. EXAMPLES OF RECENT AND ONGOING AQUACULTURE RESEARCH (AQUAFISH INNOVATION LAB) PROJECTS				
COUNTRY	PROJECT NAME	FOCUS AREA(S)	FUNDING TYPE	TIME FRAME
AFRICA				
Kenya **Uganda**	Aquaculture Development in Kenya and Uganda: Advancing Cost-effective Technology, Market Assessment, and End-user Engagement	Livelihoods Small-scale aquaculture Supply/value chain analysis Gender capacity building	Feed the Future (USAID Bureau of Food Security)	2013 - 2018
Ghana **Tanzania**	Aquaculture Development and the Impact on Food Supply, Nutrition, and Health	Human health and nutrition Food quality and safety Sustainable fish feed Value chain analysis Pond aquaculture	Feed the Future (USAID Bureau of Food Security)	2013 - 2018
ASIA				
Bangladesh	Enhancing Aquaculture Production	Food security	Feed the Future (USAID Bureau of Food Security)	2013 - 2018

TABLE A 2. EXAMPLES OF RECENT AND ONGOING AQUACULTURE RESEARCH (AQUAFISH INNOVATION LAB) PROJECTS				
COUNTRY	PROJECT NAME	FOCUS AREA(S)	FUNDING TYPE	TIME FRAME
	Efficiency, Sustainability, and Adaptive Measures to Climate Change Impacts	Sustainable Aquaculture Livelihoods Climate change adaptation Capacity building		
Burma	Sustainable Inland Fisheries for Burmese Food Security in an Era of Global Change	US-based desk study with existing data Role of inland fisheries and aquaculture in nutrition and food security Climate risk assessment.	Feed the Future (USAID Bureau of Food Security)	2016-2018
Cambodia Vietnam	Improving Food Security, Household Nutrition, and Trade Through Sustainable Aquaculture and Aquatic Resource Management	Food Security Sustainable freshwater aquaculture Livelihoods Climate change adaptation Aquatic resource management Snakehead aquaculture	Feed the Future (USAID Bureau of Food Security)	2013 - 2018

TABLE A 2. EXAMPLES OF RECENT AND ONGOING AQUACULTURE RESEARCH (AQUAFISH INNOVATION LAB) PROJECTS				
COUNTRY	PROJECT NAME	FOCUS AREA(S)	FUNDING TYPE	TIME FRAME
		Value-added processing techniques Gender		
Nepal	Advancing Aquaculture Systems in Nepal for more Social and Environmental Sustainability	Food Security Small-scale aquaculture Pond polyculture Supply chain (seed source)	Feed the Future (USAID Bureau of Food Security)	2013 - 2018

ANNEX II: AQUATIC ECOSYSTEM GOODS AND SERVICES, AND ASSOCIATED ADVERSE IMPACTS FROM CAPTURE FISHERIES AND AQUACULTURE

Ecosystem Goods and Services Types		Fisheries		Aquaculture-Mariculture	
		Ecosystem Goods and Services from Marine Environments	Adverse Impacts	Ecosystem Goods and Services from Coastal and Freshwater Environments	Adverse Impacts
Provisioning	Food	Fish, shellfish, and seaweed for human consumption as food	Overfishing and bycatch may degrade the ecological and economic viability of the fishery, reducing natural productivity, and food security, and including reduced genetic diversity, reproductive rates, or growth and maturation processes. All of which threaten ongoing food security. Abandoned fishing gear (ghost nets), collisions with sea life, and use of toxic substances (cyanide) may also degrade food webs.	Fish, shellfish, and seaweed for human consumption as food	Introduction of exotic or invasive species may lead to direct predation on commercially or cultural significant species. Over-harvest of lower-level aquatic food web species (e.g., krill, anchovies, sardines) for feedstock may degrade ocean ecosystems.
	Medicinal Resources	Marine-derived pharmaceuticals		Marine-derived pharmaceuticals (carrageenan)	
	Ornamental Resources	Shells, pearls, aquarium fish, or coral		Shells, pearls, aquarium fish, or coral	
	Energy and Raw Materials	Algae used for non-food purposes (fertilizer, energy)		Algae used for non-food purposes (fertilizer, energy).	
	Water Storage			Aquaculture ponds may retain water for irrigation during dry seasons.	Aquaculture ponds may remove or divert water from natural systems and human use
Regulating	Air Quality	The oceans produce 50% of the oxygen we breathe.	Motor vessels (especially diesel) produce pollutants such as nitrous oxides and fine particulate matter negatively impacting air quality.	Healthy coastal ecosystems purify the air of contaminants (dust, foul odors).	Overstocking may generate excess ammonia and other odors. Abandoned aquaculture ponds may produce windblown fine particulates from dried pond bottoms.
	Biological Control	Resilient food webs sustain high-value species and control	Overfishing and bycatch of some predator species may allow opportunistic	Fish-rice polycultures provide pest control as the fish feed freely in flooded fields.	Impacts on species which limit populations of opportunistic species such as jellyfish or squid.

Ecosystem Goods and Services Types	Fisheries		Aquaculture-Mariculture	
	Ecosystem Goods and Services from Marine Environments	Adverse Impacts	Ecosystem Goods and Services from Coastal and Freshwater Environments	Adverse Impacts
	opportunistic species	species such as jellyfish or squid to thrive	Filtering coastal water by shellfish may reduce pathogen populations.	Sewage-fish aquaculture and overstocking in both pond and open pens may allow pathogenic organisms to thrive.
Climate Stability	Marine ecosystems are large components of the global hydrological cycle, extra-regional weather patterns and local and regional climate (moderating temperatures)		Both marine and freshwater ecosystems often influence local and regional climate (moderating temperatures)	Degrading or destroying mangrove ecosystems leads to large losses stored carbon.
Disaster Risk Reduction	Coral reefs, mangrove forests, kelp forests dampen and attenuate waves, reducing breaking wave velocity	Overfishing can reduce the resilience of coral reefs; mangroves can be overharvested for fish smoking and processing; kelp may be overharvested, and disruptions to the food web may allow aggressive feeders (sea urchins) to decimate kelp ecosystems	Coastal communities face reduced storm surge where coral reefs, mangrove forests, kelp forests, and other coastal ecosystems remain intact	Degrading or destroying coral reefs, mangrove forests and other coastal ecosystems reduces storm surge protection for coastal communities.
Dispersal of genetic materials, ambient fertilization	Dispersal of gametes, larvae, and angiosperm by currents and tides supports basic reproductive processes and intra-species diversity	Disruptions to local currents (overharvesting kelp) may impact reproductive processes of other species	Dispersal of gametes, larvae, and angiosperm by surface water supports basic reproductive processes and intra-species diversity.	Disruptions to local currents (diversions, artificial ponds) may impact reproductive processes of other species
Soil Formation	Detritus (whale falls) and other nutrients support benthic food webs	Removal of wetlands and dredging for navigation may disrupt soil formation processes in both	Detritus and other nutrients support benthic food webs	Degrading or destroying mangrove and other wetland ecosystems disrupts soil-building processes.

Ecosystem Goods and Services Types	Fisheries		Aquaculture-Mariculture	
	Ecosystem Goods and Services from Marine Environments	Adverse Impacts	Ecosystem Goods and Services from Coastal and Freshwater Environments	Adverse Impacts
		wetlands and benthic systems.		
Soil Quality		Nutrient cycling within ocean sediments may be impacted from dredging, trawling	Integrated, extensive ag-aquaculture systems (fish-rice polycultures) contribute nutrients directly to agricultural soils. Irrigation from nutrient-rich aquaculture ponds may also contribute to soil fertility.	Excess waste below fish pens may create anoxic benthic conditions. Irrigation from brackish aquaculture ponds may salinize or acidify agricultural soils.
Soil Retention	Coral reefs and calcareous algae supply sand for beaches and tourism?	Coastal kelp forests reduce sand scouring potential along coasts		Degrading or destroying mangrove and other wetland ecosystems may cause significant erosion.
Water Quality	Nutrient cycling in ocean waters supports healthy marine habitats	Shipwrecks and spills (fuel, oil) may degrade water quality locally or regionally	Filtering coastal water by shellfish can improve water quality in healthy marine habitats.	May contribute excess nutrients, leading to groundwater pollution, algal blooms, and eutrophication, reducing dissolved oxygen in both natural and cultivated systems. Suspended solids may also degrade water quality. Health risks from algal blooms may be concentrated and extended by shellfish populations.
Water Capture, Conveyance, and Supply	Tides move water throughout intertidal zones, supporting intertidal species and habitat	Changes to aquatic vegetation may impact local currents and surface water flows.	Surface water flows are a major source of water for all terrestrial uses	Infrastructure (diversions, impoundments) has a direct effect on surface water flows
Navigation		Lost fishing gear (ghost nets) may reduce natural productivity of habitats, foul boat propellers, or even present a navigational hazard.		Coastal pens – especially degraded or abandoned pens – may present navigation hazards.

Ecosystem Goods and Services Types		Fisheries		Aquaculture-Mariculture	
		Ecosystem Goods and Services from Marine Environments	Adverse Impacts	Ecosystem Goods and Services from Coastal and Freshwater Environments	Adverse Impacts
Supporting	Habitat and Nursery	Habitat is critical to sustaining resilient populations of fish, shellfish, and seaweed – including species which may not have direct economic or cultural value, but which are important to ecosystem function overall. Species may live in multiple habitats during their full lifecycle – habitat for adults often differs from breeding and nursery habitat(s) for the same species.	Lost fishing gear (ghost nets) may create hazards within critical habitat, including reefs and ocean banks. Similarly, use of toxic substances (cyanide) degrades habitat. Destruction of reefs, shoals, and inshore habitat may harm critical breeding and nursery habitat for commercial and other critical species. Trawling may damage habitat for lower-level aquatic food web (e.g., eelgrass, benthic communities) which support the food chain.	Habitat is critical to sustaining resilient populations of fish, shellfish, and seaweed – including species which may not have direct economic or cultural value, but which are important to ecosystem function overall. Species may live in multiple habitats during their full lifecycle – habitat for adults often differs from breeding and nursery habitat(s) for the same species.	Exotic/invasive species may out-compete commercially or cultural significant species Excess nutrients from intensive systems may degrade natural habitat (eutrophication) Destruction of reef, coastal, and inshore habitat may harm critical breeding and nursery habitat Dredging may damage habitat for lower-level aquatic food web (e.g., eelgrass, benthic communities) which support the food chain.
Information	Aesthetic Information	Views of healthy marine and coastal ecosystems are highly valued	Protecting coral reefs and beaches which appeal to individual observers	Views of healthy coastal and freshwater ecosystems are highly valued	Protecting coral reefs, beaches, and wetlands which appeal to individual observers
	Cultural Value	Subsistence or traditional use of fish, shellfish, and seaweed. Traditional livelihoods.	Overharvesting for commercial markets may degrade or destroy traditional livelihoods.	Traditional ag-aquaculture systems (fish-rice polycultures)	Aquaculture may displace or out-compete traditional livelihoods.
	Recreation and Tourism	Fishing as a pastime; fishing culture as tourism attraction.	Impacts on bird or whale watching, SCUBA diving, sailing, etc.	Fishing as a pastime; fishing culture as tourism attraction.	Potential impacts on nature-based tourism (pollution, habitat degradation), impacts on charismatic species
	Science and Education	Research on marine ecosystems informs engineering and education		Research on aquatic ecosystems informs engineering and education Aquaculture systems are researched for innovation	

Ecosystem Goods and Services Types		Fisheries		Aquaculture-Mariculture	
		Ecosystem Goods and Services from Marine Environments	Adverse Impacts	Ecosystem Goods and Services from Coastal and Freshwater Environments	Adverse Impacts
				potential, as well as the monitoring of externalities.	