Economics of Fisheries and Aquaculture in the Coral Triangle

ADB

Australian Aid

CORAL TRIANGLE INITIATIVE
ON CORAL REEFS, FISHERIES AND FOOD SECURITY

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6 ADB Avenue, Mandaluyong City
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Tel +63 2 632 4444
Fax +63 2 636 2444
www.adb.org

For orders, please contact:
Public Information Center
Fax +63 2 636 2584
adbpub@adb.org

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Foreword

The Coral Triangle Initiative on Coral Reefs, Fisheries, and Food Security (referred to in this report as Coral Triangle Initiative [CTI]) was launched in 2007 as a multilateral partnership of the governments of Indonesia, Malaysia, Papua New Guinea, the Philippines, Solomon Islands, and Timor-Leste. One of the major goals of the CTI is safeguarding the coastal and marine resources of the seas that surround these countries, which together comprise an oceanic expanse of 5.7 million square kilometers known as the Coral Triangle.

This region is unique in that it contains a greater degree of marine biodiversity than anywhere else on earth. It is also home to more than 350 million people, more than one-third of whom directly depend on coastal ecosystems and marine resources for food and livelihood. The CTI aims to ensure food security and sustainable livelihoods for all residents of the Coral Triangle, and protect its unique ecosystems and the marine species that inhabit them in perpetuity.

At the first CTI Senior Officials Meeting in Bali, Indonesia, in December 2007, Indonesian President Susilo Bambang Yudhoyono requested for financial and technical assistance to achieve the CTI's objectives. Responding to this request, the Asian Development Bank (ADB) emerged as a core CTI development partner, and became one of the agencies helping the CTI access financial support from the Global Environment Facility. ADB's response was welcomed, given its long-term commitment to sustainable development of coastal and marine resources, as well as its many decades of experience in coastal and marine resource management in Southeast Asia and the Pacific. Further, ADB has subsequently undertaken a number of loan, grant, and technical assistance initiatives that directly support and complement the CTI. These initiatives help strengthen regional policy dialogue, facilitate CTI-wide exchange of data and information, build institutional capacity, and encourage policy and program development based on global best practice.

ADB's technical assistance—Regional Cooperation on Knowledge Management, Policy and Institutional Support to the CTI—was the first support of its type to the program, directly strengthening cooperation among the six Coral Triangle countries in implementing policies, institutions, and investments to achieve sustainable management of the Coral Triangle's coastal and marine ecosystems. True to its title, one of the major issues addressed by this technical assistance was lack of access to information necessary for efficient policy and decision making as it relates to CTI objectives.

An outgrowth of this assistance and the first report of its type, *Economics of Fisheries and Aquaculture in the Coral Triangle* (EFACT) consolidates all primary and secondary knowledge relating to fisheries and aquaculture in the Coral Triangle into a single volume. Further, this report synthesizes existing knowledge with data and information not previously available—data and information derived from primary data collection supported by an ADB-sponsored regional technical assistance initiative with additional financial support from the Australian government. Using sound analytical tools borrowed from economics, this report takes a regional perspective in analyzing all currently available information that relates to the Coral Triangle marine ecosystem, and perhaps more importantly, its economic parameters.

For example, the EFACT report estimates the contribution of the Coral Triangle to global aquatic production at 19 million tons per year, more than 60% of which is food fish sourced primarily from capture fisheries. While such a level of annual output is impressive, it hides the fact that the majority of Coral Triangle fish stocks are at the minimum, fully exploited. From a broader perspective, this implies that the six Coral Triangle countries are heavily interconnected ecologically, but that their economic linkages are far weaker by comparison. Thus, given increasing demand from natural rates of population increase—and even more rapid growth in per capita income in some Coral Triangle countries—depletion of Coral Triangle fish stocks is not only a major concern, but one that highlights the need for greater economic integration on the part of six CTI countries.

In a similar vein, the EFACT report devotes special attention to the small-scale fisheries subsector in the Coral Triangle economies, as this subsector accounts for the bulk of employment in their fisheries sectors. Likewise, using case studies performed in the Philippines, Solomon Islands, and Timor-Leste, the report proposes cost-efficient data collection methods, and emphasizes the food security aspect of food fish production, particularly as it relates to poor, isolated communities. This latter aspect of the analysis is important, since food fish output in such communities substantially contributes to household per capita income and thus enables increases in non-food consumption.

In highlighting the economic value of marine resources such as coral reefs, the report underscores the significant role of the retail sector in advanced countries in shaping the behavior of small-scale exploiters of Coral Triangle reef resources, the ecological impact of which is less than optimal. On a more positive note, the report explains the role that international trade might play in encouraging sustainable fish-harvesting methods at small scale such as the hand-lining of tuna.

The *Regional Call to Action* that concludes the report recommends eight regional actions that relate to several themes: (i) support for a common fisheries policy framework, (ii) the necessity of viewing aquaculture from the perspective of long-term sustainability, (iii) strengthening institutional linkages with agencies outside the CTI, and (iv) expanding the knowledge-sharing and decision-making platform beyond that which currently exists. All of recommended actions support regional policy dialogue and coordination among national governments and regional entities in resolving cross-border issues that directly impact sustainability of the Coral Triangle's economy and marine ecosystem. Ultimately, the EFACT report sees the importance of these latter outcomes as being their ability to contribute to poverty reduction in the Coral Triangle over the long term.

ADB is keen to support actions at the national and regional levels that lead to poverty reduction and long-term sustainable management of the Coral Triangle's marine resources. Similarly, ADB wishes to provide all support possible to those who seek to fulfil the national and regional action plans that form the core of the CTI. Further, ADB stands ready to provide such support through financial assistance, knowledge management, and capacity building as appropriate.

We sincerely hope that this EFACT report will help policy makers in Coral Triangle countries and their development partners who influence investment decisions to better appreciate the central role of fisheries and aquaculture in Coral Triangle economies. More importantly, we hope that the analysis this EFACT report provides will help achieve the CTI's long-term objectives, which are healthy coral reef ecosystems, sustainably managed fisheries, and food security for all 350 million of the Coral Triangle's residents.

James A. Nugent
Director General
Southeast Asia Department
Asian Development Bank

Xianbin Yao
Director General
Pacific Department
Asian Development Bank

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The report was finalized under the technical direction and supervision of ADB staff—Pavit Ramachandran, senior environment specialist, Southeast Asia Department; and Marilou Drilon, senior natural resources economist, Pacific Department.

Executive Summary

The *Economics of Fisheries and Aquaculture in the Coral Triangle* (EFACT) is the first report of its kind that consolidates primary and secondary information on fisheries and aquaculture using a regional lens and analytical tools from economics. The EFACT is an output of the Asian Development Bank (ADB) technical assistance—Regional Cooperation on Knowledge Management, Policy, and Institutional Support to the Coral Triangle Initiative (CTI).

As a knowledge product derived from 3 years of work in the CTI through the technical assistance project, the EFACT aims to inform actions and policy discourse in the implementation of the CTI regional plan of action (RPOA) and the national plans of action (NPOAs) of the six Coral Triangle countries (CT6) comprising Indonesia, Malaysia, Papua New Guinea (PNG), the Philippines, Solomon Islands, and Timor-Leste. New knowledge was derived through primary data collection and existing knowledge was organized and analyzed from a regional perspective using an economic lens. The report concludes with a regional call to action.

Fish Production in the Coral Triangle: Status, Trends, and Challenges

In 2011, coastal fishery resources provided food, sustained incomes, and fueled trade and enterprise for an estimated 373 million people living in the CT6 countries, a third of whom reside within 10 kilometers (km) of the coastline. In the same year, the CT6 countries contributed 11.3% (19.1 million tons [t]) to global capture fisheries and aquaculture production. Of this, 69% (13.2 million t) consisted of food fish, representing 10% of the global food supply, while the rest consisted of aquatic plants. Most food fishes are obtained from the marine environment through capture fisheries (69%) and marine and brackishwater aquaculture (13%).

Fish and aquatic invertebrates are important protein sources for many countries in Asia and the Pacific. Fish per capita supply of Indonesia, Malaysia, and the Philippines remained above the average values for Asia in 2009; and has been increasing since 1961, with Malaysia showing the fastest rate of increase, followed by the Philippines and Indonesia. In Solomon Islands, fish per capita supply was also higher compared to the Oceania average, but this was not the case for PNG and Timor-Leste.

Fisheries and aquaculture employ at least 4.6 million people in CT6 countries, representing 1.3% of the aggregate CT6 population, or 2.0% of total persons employed in CT6 countries in 2009. Assuming an average household size of four, the total number of the population directly dependent on fisheries for livelihood in the Coral Triangle was about 18.4 million, or 5% of the aggregate CT6 population in 2009.

Fisheries and aquaculture production in CT6 countries contributes between 1.2% and 6.8% of gross domestic product, although issues pertaining to the collection of official statistics abound. Two key issues surrounding fishery statistics are the difficulty of estimating the volume and value of subsistence fisheries; and the lack of coordination between fisheries and statistics and/or planning agencies, which affects the credibility of numbers.

Of the fisheries production in CT6 countries, mackerels (scombrids), anchovies, and sardines (clupeoids) comprise 53%, while reef-associated species account for 32%. Tuna is an important fishery commodity in the Coral Triangle. In 2009, 46% of all tuna catches in the Western and Central Pacific—valued at $1.5 billion—came from the national waters of Indonesia, PNG, the Philippines, and Solomon Islands. In both PNG and Solomon Islands, tuna catches by foreign fleets were greater than those by their respective national fleets.

One of the unique features of the fisheries of CT6 countries is the diversity of their marine fishery resources that are extracted, consumed locally, processed, and exported. More than 2,500 species of reef-associated fish can be found in the Coral Triangle and are exploited for sale or subsistence. The value of coral reefs to capture fisheries production in the Coral Triangle was estimated by (i) identifying reef-associated fish catches in the data set of the Food and Agriculture Organization of the United Nations (FAO), (ii) determining the percentage composition of reef-associated fishes in the total capture fisheries production for each country, and (iii) multiplying the reported total value of capture fisheries by these percentages using a conversion factor for the relative value of reef-associated fishes to pelagic fishes.

Reef-associated fishes in CT6 countries are valued at $3.0 billion or 30% of the total capture fisheries value in the region. This value could even be larger if the reef-associated prey consumption of tuna, estimated at $150 million for CT6 countries, is taken into account.

CT6 fish production has been consistently increasing, with an annual growth rate of 4.8% from 1953 to 2003, and 8.0% from 2004 to 2010. While global capture fisheries production appears to have leveled off since 1986, CT6 capture fisheries production continues to rise, although the rate of growth has slowed down. The rapid increase in total fisheries production in CT6 countries from 2004 to 2009 was primarily due to the development of aquaculture in Indonesia and the Philippines.

The increasing trends in production for marine capture fisheries and aquaculture can be misleading in that fishing in CT6 countries is sustainable and well within carrying capacity limits. The paucity of time series data on fishing and production costs and the level of effort put into the capture and culture of fishes, marine invertebrates, and aquatic plants obscure the true state of fisheries in these countries.

A recent FAO report on the status of world marine fishery resources concluded that the majority of fish stocks in Indonesia, Malaysia, and the Philippines are considered to be at least fully exploited. Demersal finfish fisheries of CT6 countries are mostly fully exploited or overexploited. This is true in Indonesia, where overfishing occurs in 5 out of 11 designated fisheries management areas. In Malaysia, scientific surveys conducted during 1972–1998 in Peninsular Malaysia and Sarawak indicated widespread overexploitation and depletion of fishery resources. In the Philippines, demersal finfish resources experienced steep declines of up to 64% between the 1940s and 1990s. Assessments by the Western and Central Pacific Fisheries Commission in 2010 indicate possible overfishing of bigeye tuna (*Thunnus obesus*) based on mortality estimates.

Using varied scenarios for historical production trends for capture fisheries and aquaculture, fish and invertebrate production in CT6 countries is estimated to increase to a moderate value of 17.1 million t by 2020, ranging from 15.5 million t to 19.4 million t, compared to the production of 13.2 million t in 2010. Based on population projections, the estimated fish production could mean an annual per capita fish supply of 33.0–45.0 kilograms (kg) after accounting for the projected balance of trade. The projected growth in fish production comes from an expansion of aquaculture, rather than capture fisheries production. In CT6 countries, fish per capita supply is also projected using two time frames, in 2001–2010 and 2007–2009. On average, per capita fish supply in CT6 countries increased by 32% in 2001–2010 and 44% in 2007–2009. The increase in Timor-Leste was consistent for both periods, registering at least 70%, and with the government's aggressive efforts to improve productivity in both fish capture and culture.

Aquaculture Development Trends and Implications

Aquaculture is seen by most CT6 countries as contributing to food security, poverty alleviation, and export revenues; but the CTI RPOA has been silent on its benefits and impacts while the NPOAs have given varied treatments. This report focused on the demand of aquaculture for trash fish for reduction purposes, but recognized other interactions between capture fisheries and aquaculture. These include (i) introduction of alien species mainly for aquaculture but with risks of escape, disease, damage to habitats, and wild biodiversity; (ii) pollution; (iii) biotechnology concerns (transgenic fish); and (iv) capture-based aquaculture (collection of juvenile for grow-out, such as in the live reef fish industry).

Notable are the different aquaculture strategies employed by the CT6 countries: the Coral Triangle Pacific (CT-Pacific) countries are more focused on the expansion of freshwater aquaculture, while Coral Triangle Southeast Asian (CT-SEA) countries are more concentrated on high-value carnivorous species. Aside from production and economic inefficiencies, the increasing demand for trash fish has numerous impacts on the levels of harvesting and consumption of commercial species. The fish kills in the Philippines, which can be ultimately traced to an overheated aquaculture sector, are a case in point. While the damages associated with fish kills are localized and appear insignificant when compared to the total sector revenues, what is missing in the analysis are the costs associated with linkages to other economic sectors, losses incurred by various government agencies, and the opportunity costs.

The use of an economic lens in analyzing the interactions between capture fisheries and aquaculture is important because economic incentives guide the actions of private decision makers—fishers, fish processors, feed suppliers, and fish farmers. Economic analysis informs the optimal use of scarce resources, and policy making uses economic instruments to monitor the attainment of objectives.

Connectivities in the Coral Triangle

CT6 countries are connected in the biophysical, institutional, and economic realms. Biophysical connectivities in the Coral Triangle are depicted by (i) migration of animals between habitat patches, such as turtles and tunas; and (ii) dispersal of larvae from spawning locations to downstream habitats. Although demographic connectivity studies in the Indo–West Pacific indicate a high overall level of self-recruitment, there are notable connectivities representing clusters of larval exchanges (i) in certain areas in the South China Sea, (ii) on reefs in the western part of the Coral Triangle between Java–Sulu archipelago and the Bismarck–Banda Sea and the eastern portions of Banda Sea, and (iii) between the reefs of PNG and Solomon Islands. In-country conservation efforts are as important as regional action given that coral reefs are largely self-recruiting.

Economic connectivities are demonstrated by trade between and among the CT6 countries, and between the individual Coral Triangle countries and the rest of the world. The volume of trade in fish and fishery products among CT6 countries is less than the trade with countries outside the Coral Triangle. For CT6 countries, as a region trading with the rest of the world, there was a consistent surplus in the 9-year period, 2000–2008, which increased by about 60%, for an average of 7.5% increase per annum. Total volume of production exported to other countries varied among CT6 countries. The Philippines exported only 7% of its total fish production, while PNG and Solomon Islands exported more than half of the catches from their domestic fleets.

Multilateral and bilateral fisheries-related agreements exist among the CT-SEA countries and among the CT-Pacific countries, but similar agreements between them remain scarce. The CTI position as a global trader can be further enhanced through tighter organization, application of common policies (including price policies), development of CTI brands, and product differentiation and certification.

Subsistence Fisheries in the Coral Triangle

In this report, subsistence fisheries in CT6 countries are given attention, recognizing these issues identified by the FAO: they are underreported, undervalued, "notoriously" difficult to manage, and not fully considered in the development dialogue. Yet, the numbers that characterize subsistence fisheries are "too big to ignore" in terms of people involved in the sector, production volumes and values, and contribution to household nutrition and incomes.

In Solomon Islands, nearly half of all women and 90% of men in many rural households engage in fishing. This study estimated that a minimum of 88,000 people are engaged in fishing, assuming one household member; and 175,000 people, assuming the inputs of women and other adult men in their households, which is almost half of the country's population. Using data from a survey conducted by the WorldFish Center (WorldFish) in Solomon Islands and the EFACT study, the use and nonuse values of coral reefs were estimated in four communities in the Western and Central provinces. Two communities have a history of aquarium and curio trade. Coral reefs provide an average of SI$18,000–SI$75,000 ($2,472–$10,302) per respondent per year, consisting of food (mainly reef fish), materials, and trade. Food items derived from reefs yield an average subsistence and cash value of SI$9,600–SI$43,000 ($1,320–$5,900) per respondent per year across the four study sites. Using the estimate of 88,000 people involved in fishing and extrapolating this figure for four villages, the subsistence and cash value of reef fish is estimated at SI$300–SI$1,000 million per year ($41–$145 million per year), with the lower estimate comprising roughly 20% of the value of production in 2007.

In Timor-Leste, a survey of capture fisheries households in the Liquica District (Suco Dato) was conducted in August 2012 to (i) obtain the level of dependency of village households on fisheries-related activities for their livelihoods; and (ii) enhance the capacity of the Ministry of Agriculture and Fisheries to design, plan, and implement a national fisheries household census. Based on the FAO and WorldFish (2008) nomenclature of categories of fishers, the survey respondents fulfilled most of the criteria for subsistence fisheries, which included the size of boat, number of crew, gear type, ownership, and time spent in fishing. The exceptions were on the (i) disposal of catch because the survey respondents' catches were primarily for sale, with a portion for domestic and/or own consumption; and (ii) households' integration into the economy since much of the fishing and disposal was via market channels. Overall, the profiles indicate that subsistence fisheries dominate, with some larger-scale and more commercial fishing activities.

Subsistence fisheries in the Philippines conform more to the FAO/WorldFish characterization, where production does not enter the market either by choice (such as when fish is consumed at home or traded or given away as gifts) or by location (when the location is not accessible to ready markets either by geography or absence of market infrastructure). Based on an average daily catch of 0.5 kg/day and assuming that 10% is consumed by households, total fish production in support of household food needs is about 195,000 t/year for the Philippines, with the value representing 22% of the food poverty threshold level.

Small-scale fishing, which accounts for bulk of employment in the sector in the Coral Triangle, is much more significant as a source of livelihood, food security, and income than is often realized. In terms of the estimated distribution of small fishers across Asia, approximately 38% are from Southeast Asia. It is estimated that when full-time, part-time, and seasonal men and women fishers are included, there may be more than 15 million small-scale fishers in the Coral Triangle region. Assuming that each household has five members, of whom at least one person is engaged in fishing, it is estimated that 75 million people in the region are directly dependent on fisheries for food, income, and livelihood.

Fisheries Value Retention for Highly Traded Commodities

Opportunities exist for small fishers in CT6 countries to improve their incomes as a result of globalization and trade. An example is the live reef fish trade and tuna handlining in the Philippines, where value retention is an average of 20% for live reef fish when fishing and caging are combined, and a range from 17% to 21% for the handliners in Mindoro Straits and Lagonoy Gulf. Although small when compared with the shares of other participants in the value chain, the incomes generated can very well breach the poverty threshold; and provide sufficient disposable income for education, clothing, and household appliances. Compliance with sustainability criteria is one way of value addition, as experienced in the tuna handlining sector. The live reef fish trade, although profitable for fishers and cagers, hastens overexploitation of wild grouper because of the preference for juveniles, which are cheaper and can be caged. Comparing this value retention with coral trade in Solomon Islands, a harvester earns only 1%–2% of the total product value due to huge transport costs and market isolation. Nevertheless, the analysis shows that coral trade is an important source of cash income in the communities that enables them to support their nonfood requirements. Options to improve value addition, adherence to economies of scale, and full government support can reinvigorate interest in coral farming as an alternative to wild harvest.

Assuring Sustainable Fisheries Development through Ecosystem Resiliency and Food Security

Despite the importance of the Coral Triangle as a supplier of fish to the world, food security objectives remain a challenge due to the myriad anthropogenic and climatic threats that plague the region. CT6 countries have high socioeconomic vulnerability, considering that 16.6% of the populations are poor and about 13.0% are undernourished. Poverty incidence in the coastal fishing communities is generally higher than the national average, and the climate change risk is high. In many of the CT-Pacific countries, importation of food is increasing because of declining per capita production of food caused by rural–urban migration and changing food preferences.

Fisheries sustainability is affected by several drivers, the most important being weak governance, socioeconomic conditions, and ecosystem change. Illegal, unregulated, and unreported (IUU) fishing is a confluence of these drivers; and it results in significant economic losses, as measured by opportunity costs, faster pace of resource degradation, and unequal resource distribution. Some studies have estimated worldwide annual production from IUU operations ranging from 11 million t to 26 million t, accounting for about 10%–22% of the world's total fisheries production and valued at about $10.0 billion–$23.5 billion per year.

Results of a mini survey conducted by the EFACT study among fisheries officials and staff, researchers, and experts in CT6 countries showed that fisheries management in the Coral Triangle employs both input and output controls, as well as some conservation measures that can be classified under ecosystem approach to fisheries management (EAFM). Input controls are more commonly employed in CT6 countries than regulations on catch rates and catch volumes. Limits on fishing grounds through zoning, establishment of fish sanctuaries or fishing exclusion zones, and protection of critical fish habitats and spawning aggregation sites are implemented in all CT6 countries to varying extents and degrees of enforcement. Conservation measures are also being implemented, including seasonal closures in observance of important fish life cycle stages, fish habitat restoration strategies, restocking of fish species, and banning of catching of some species of fish and invertebrates. Subsidies are implemented primarily by the CT-SEA countries, but are not apparent in CT-Pacific countries; while traditional fishery management measures are more widely applied in the CT-Pacific than in CT-SEA countries. Output controls are least employed by CT6 countries, owing mainly to the multispecies and multigear nature of the fisheries; and the presence of significant numbers of small-scale and subsistence fishers, making the implementation of catch quotas very difficult.

Five key strategies are put forward among the many that should be undertaken to address vulnerabilities in coastal fishing communities. These are

(i) rights-based management,
(ii) livelihood approaches,
(iii) social marketing,

(iv) resource restoration, and
(v) good governance.

The complementarity and synergistic impacts of these strategies, when integrated and considered holistically, are embedded in the EAFM approach. It can involve scaling-up or scaling-down efforts, depending on the ecosystem in question. In the CTI setting, many sector-specific management interventions are already in place, but the process of integrating or upscaling of these efforts remains a challenge.

Scaling-up in EAFM can be categorized in three broad areas: (i) geographical expansion, (ii) functional expansion, and (iii) temporal expansion. Geographical expansion can involve integrating management from the town or barangay to the bay-wide, municipality, or networks of towns. It can also involve expansion from protecting a single marine habitat (e.g., coral reefs) to considering other important habitats such as seagrass and mangrove forests. Functional expansion can be in the form of a livelihood approach that explores the properties of networks of families and communities. Temporal expansion involves going beyond the standard monitoring process to one that considers future scenarios that consider climate change impacts.

Abbreviations

AASI	–	Aquarium Arts Solomon Islands
ACIAR	–	Australian Centre for International Agricultural Research
ADB	–	Asian Development Bank
APEC	–	Asia-Pacific Economic Cooperation
ASEAN	–	Association of Southeast Asian Nations
ASFIS	–	Aquatic Sciences and Fisheries Information System
BAS	–	Bureau of Agricultural Statistics (Philippines)
BFAR	–	Bureau of Fisheries and Aquatic Resources (Philippines)
CITES	–	Convention on International Trade in Endangered Species of Wild Fauna and Flora
CPUE	–	catch per unit effort
CTI	–	Coral Triangle Initiative on Coral Reefs, Fisheries, and Food Security
CT6	–	six countries in the Coral Triangle region (Indonesia, Malaysia, Papua New Guinea, Philippines, Solomon Islands, and Timor-Leste)
CT-SEA	–	Coral Triangle Southeast Asia (Indonesia, Malaysia, Philippines)
CT-Pacific	–	Coral Triangle Pacific (Papua New Guinea, Solomon Islands, Timor-Leste
EAFM	–	ecosystem approach to fisheries management
EBM	–	ecosystem-based management
EFACT	–	Economics of Fisheries and Aquaculture in the Coral Triangle
FAO	–	Food and Agriculture Organization of the United Nations
FFA	–	Fisheries Forum Agency
FGD	–	focus group discussion
FOB	–	free-on-board
GDP	–	gross domestic product
gt	–	gross ton
ISSCAAP	–	International Standard Statistical Classification of Aquatic Animals and Plants
IUU	–	illegal, unreported, and unregulated
kg	–	kilogram
km	–	kilometer
LGU	–	local government unit
LRF	–	live reef fish
LRFT	–	live reef fish trade
MAF	–	Ministry of Agriculture and Fisheries (Timor-Leste)
MFMR	–	Ministry of Fisheries and Marine Resources

MMAF	–	Ministry of Marine Affairs and Fisheries (Indonesia)
MPA	–	marine protected area
MSY	–	maximum sustainable yield
NAP3	–	Third National Agricultural Policy
NFRDI	–	National Fisheries Research and Development Institute
NPOA	–	national plan of action
PCSD	–	Palawan Council for Sustainable Development
PNG	–	Papua New Guinea
RPOA	–	regional plan of action
SEAFDEC	–	Southeast Asian Fisheries Development Center
SPC	–	Secretariat of the Pacific Community
t	–	ton
UNFPA	–	United Nations Population Fund
UNDP	–	United Nations Development Programme
WCPFC	–	Western and Central Pacific Fisheries Commission
WorldFish	–	WorldFish Center

I. Introduction

A. Background and Purpose of the Study

The Asian Development Bank (ADB) approved technical assistance for Regional Cooperation on Knowledge Management, Policy, and Institutional Support to the Coral Triangle Initiative (CTI) in July 2009. It was the first ADB support to the CTI to strengthen cooperation among Indonesia, Malaysia, Papua New Guinea (PNG), the Philippines, Solomon Islands, and Timor-Leste—the CT6 countries—on information exchange and decision making on coastal and marine resource management. The technical assistance had four expected outputs: (i) regional cooperation in the CTI strengthened; (ii) regional learning mechanisms established; (iii) communication and information dissemination plan implemented; and (iv) sustainable financing schemes in support of the plans of action established in the region and in each of the CT6 countries.

One of the major issues that the technical assistance aimed to address is the lack of accessible information for policy and decision making. As the national plans of action (NPOAs) of the CT6 countries are implemented, a wealth of knowledge (data, information, unique approaches to resource management, governance structures, networking, and training techniques) needs to be codified, organized, and eventually shared in a useful and understandable form.

The Australian government offered additional funding to support data collection on the economics of coastal fisheries and aquaculture in three Coral Triangle Pacific (CT-Pacific) countries—PNG, Solomon Islands, and Timor-Leste—where data are relatively scarce and less robust than in the Coral Triangle Southeast Asia (CT-SEA) countries. In mid-2011, the Australian government announced a fresh package of assistance to CT-Pacific countries, including a grant to the WorldFish Center (WorldFish) in Solomon Islands for conducting a study. It aimed to evaluate the costs and benefits associated with coral harvesting in relation to coral farming through the application of a total economic value framework and value chain analysis.

B. Features of the Study

1. Informing Actions and Policy Discourse in Implementing the Regional and National Plans of Action

The Economics of Fisheries and Aquaculture in the Coral Triangle (EFACT) study responded to the regional plan of action (RPOA) and NPOAs, specifically Goal 2 on the ecosystem approach to fisheries management (EAFM), and its Target 2 for improved income, livelihoods, and food security. The RPOA articulated the perceived interactions among population, fisheries, and biodiversity through a program dubbed "COASTFISH." In both the RPOA and NPOAs, the COASTFISH program is envisioned to address livelihoods, incomes, food security, and poverty issues at identified sites. Targeting coastal areas and designing investment programs that will contribute to poverty reduction must be planned carefully and with sufficient basis, as well as using existing initiatives as possible models or best practices.

Some of the best practices include existing modalities to fund activities of small-scale fishers, livelihood, and approaches to aquaculture management. The relevance of the EFACT study lies in generating data that will guide investment planning, specifically site selection and characterization of fisher communities (household size, density, current and potential incomes from fishing and/or fish farming and other livelihood sources, fishing practices, dependence on fisheries resources, and current fish consumption patterns).

The live reef fish trade generates millions of dollars in export revenues for CT6 countries; however, it is necessary to undertake an assessment of the trickle-down effects of pricing and how price nuances hasten the exploitation (or overexploitation) of live reef fish resources. Of interest are the income levels of fishers who catch live reef fish, and whether they are making sufficient returns compared to their inputs to the supply chain. This report presents an analysis of live reef fish, which was supported by WWF-Philippines.

Tuna is another species of interest, mainly for its transboundary implications; but also for ongoing sustainability initiatives among tuna handliners, as experienced by two provinces in the Philippines. WWF-Philippines also supported the value chain analysis, which is featured in this report.

The Timor-Leste NPOA offers several opportunities for the EFACT study to be most relevant. Its Goal 2 on EAFM includes

(i) determining the extent of dependency of coastal communities on fisheries resources,
(ii) improving their income base through alternative livelihoods and aquaculture, and
(iii) implementing community-based fisheries management schemes in priority areas.

In PNG, the NPOA is referred to as the Marine Program for Coral Reefs, Fisheries, and Food Security. Its concept of EAFM takes "into account the broader effects of fishing on the environment, as well as the effects of other sectors on fisheries and the ecosystems within which they occur." This is in contrast with traditional fisheries management, which focuses only on maximizing economic benefits. The NPOA is consistent with the EAFM framework as recognized by this study. Among the actions requiring fishery economics analysis are as follows:

(i) using tuna revenues to fund loans and projects for small-scale fisheries,
(ii) determining investment requirements to fund EAFM approaches under the COASTFISH program,
(iii) understanding the socioeconomics of tuna fishery,[1] and
(iv) providing a status report on the live reef and ornamental fish trade.

[1] Tuna fishery is not within the scope of the study funded by Australian Aid, which focuses on small-scale coastal fisheries.

Plans to update a fishery dependence survey together with The Nature Conservancy did not materialize, but knowledge gained in the tuna value chain analysis may be replicated to inform investment planning for the commercial tuna sector.

In Solomon Islands, a two-phased approach to NPOA implementation has been adopted, where Phase 1 involved the identification of pilot sites. Criteria used for selecting Phase 1 sites included human development and poverty indexes, dependency of rural population on marine resources, and subsistence indexes. Results of the valuation work on corals and the impact on subsistence fisheries have been packaged as a policy brief. Likewise, the challenge in trade of corals, including illegal trade, is an issue of interest to Indonesia and the Philippines, which can be jointly addressed through appropriate communication methods.

2. Deriving New Knowledge on the Contributions of Fisheries to the Economies of the Coral Triangle

Primary data were collected in Solomon Islands and Timor-Leste through surveys that generated information for assessing their subsistence fisheries and dependencies. In Timor-Leste, the survey was supported by Uniquest (Australia); while in Solomon Islands, the survey was implemented by WorldFish.

In the Philippines, a workshop was jointly organized by the ADB technical assistance project and WorldFish, and (i) three agencies under the Department of Agriculture—Bureau of Agricultural Statistics, Bureau of Fisheries and Aquatic Resources, and National Fisheries Research and Development Institute; (ii) selected local government units (LGUs); and (iii) local nongovernment organizations participated. The workshop reviewed the statistics collection on the state of fisheries so that national agencies could assess how local collection protocols of LGUs would be used to verify, enhance, and countercheck the survey results.

For the Coral Triangle region, the technical assistance project sent out questionnaires to determine the use and effectiveness of fisheries management interventions across CT6 countries. It included input and output controls, protection and conservation measures, subsidies, and traditional management systems. The questionnaires were disseminated through e-mail or distributed by the Uniquest knowledge integrators,[2] and some were completed during small meetings.

3. Organizing Knowledge to Provide a Regional Perspective

Existing literature and official statistics from the CT6 countries and the Food and Agriculture Organization of the United Nations were used to describe the situation in the Coral Triangle region. The work revealed several interesting aspects of fish production and trade in the CT6 countries.

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[2] ADB engaged Uniquest (Australia) through a separate contract under technical assistance (TA) 7307-REG: *Regional Cooperation on Knowledge Management, Policy, and Institutional Support to the Coral Triangle Initiative*. Uniquest fielded a team of knowledge integrators—one in each of the CT6 countries, who worked in tandem with the PRIMEX team of consultants—collecting in-country data and information, assisting in organizing workshops and other field activities, and contributing to the preparation of the required reports.

4. Recommending Regional and National Actions

Regional and national recommendations were drawn up, based on results of the EFACT study, in the areas of policy enhancement, research, institutional alignments, marketing and trade improvements, cost-effective data collection, and knowledge sharing.

II. Fish Production in the Coral Triangle: Status, Trends, and Challenges

Rollan C. Geronimo and Reniel B. Cabral

A. Socioeconomic Profile of the Coral Triangle Countries

Land and sea area. The CT6 countries that make up the Coral Triangle cover a total land area of 3.0 million square kilometers (km^2), with Indonesia having the largest land area at 1.9 million km^2 and Timor-Leste having the smallest at 14,900 km^2. In the median range are Malaysia (329,800 km^2) and the Philippines (300,000 km^2). In terms of coastline, Indonesia has the longest at 108,800 kilometers (km) and Timor-Leste has the shortest at only about 700 km. The Philippines coastline is longer (37,000 km) than that of Malaysia (4,800 km) and Solomon Islands (4,000 km). Indonesia has the largest total sea area at 5.8 million km^2 while Timor-Leste has the smallest at approximately 72,000 km^2. Among the Pacific island countries, the land area and population of Papua New Guinea (PNG) are greater than those of Solomon Islands and Timor-Leste combined; it can be considered an entirely different biophysical group and is the only country situated on a continental shelf, which it shares with Australia and Indonesia (Bell et al. 2011).

The CT6 countries exhibit a wide range of socioeconomic features. Two subclusters are apparent when looking at statistics of the countries: the larger economies of the Coral Triangle Southeast Asia (CT-SEA) countries comprising Indonesia, Malaysia, and the Philippines; and the smaller economies of the Coral Triangle Pacific (CT-Pacific) countries comprising PNG, Solomon Islands, and Timor-Leste. Coastal and fishery resources are sources of food and income for the people living in the Coral Triangle, and are inputs for the allied trade and industry sectors in the region.

Population and gross domestic product. In 2011, an estimated 373 million people lived in CT6 countries, with the largest population (almost 242 million) in Indonesia, and the smallest (almost 540,000) in Solomon Islands. A third of the population in CT6 countries lives within 10 km of the coastline and most likely dependent on coastal and fishery resources in various ways. About 8% of the CT6 population depends on fisheries and aquaculture for their direct livelihood (Table 1). Populations in CT6 countries have been growing steadily since 1960 (Figure 1). From 2007 to 2011, the population growth rate averaged 1.71%, slightly higher than the global figure for the same period (1.66%).[3] CT-Pacific countries have annual population growth rates greater than 2%. The intensive exploitation of coastal resources is an option to sustain the burgeoning population, especially when income levels do not allow import substitution. In

[3] See global population rate data from the World Bank Development Indicators. http://data.worldbank.org/data-catalog/world-development-indicators (accessed 8 February 2013).

Table 1 **CT6 Countries** Population and Dependence upon Fishing

Key Features	Indonesia	Malaysia	Papua New Guinea	Philippines	Solomon Islands	Timor-Leste	Total
2011 population (million)[a]	241,600,000	28,990,000	7,000,000	94,185,000	539,852	1,092,109	373,406,961
Land area (km^2)	1,900,000	329,847	300,000	460,000	28,000	14,874	3,032,721
Population density (people/ land area in km^2) (2009)	122	85	14	307	18	70	118
Mean annual population growth rate (%) (2007–2011)	1.40	1.78	2.80	1.77	2.35	2.44	1.71
% of population living within 10 km of coastline[b]	28	32	23	47	84	53	33
Population living within 10 km of coastline[b]	64,783,600	8,928,000	1,460,040	43,346,502	433,331	551,166	119,502,639
Capture fisheries employment (primary sector)	2,641,566[c]	125,632[d]	120,000	1,388,173[e]	5,114	7,600	4,927,704
Aquaculture employment (primary sector)	2,493,193[f]	...	...	226,195	...	...	2,719,388
% of population dependent on fisheries and aquaculture[g]	8.9	1.8	9.5	7.0	5.0[h]	3.7	7.8

--- = data not available, km = kilometer, km^2 = square kilometer.

[a] ADB (2011). Statistics and Database. http:www.adb.org/statistics/

[b] Center for International Earth Science Information Network (CIESIN) (2007).

[c] Employment in the secondary sector is estimated to be 1,164,178 in 2005 (Food and Agriculture Organization of the United Nations [FAO]). http://www.fao.org/fishery/countrysector/FI-CP_ID/en

[d] Number of fishers working on licensed fishing vessels (2009).

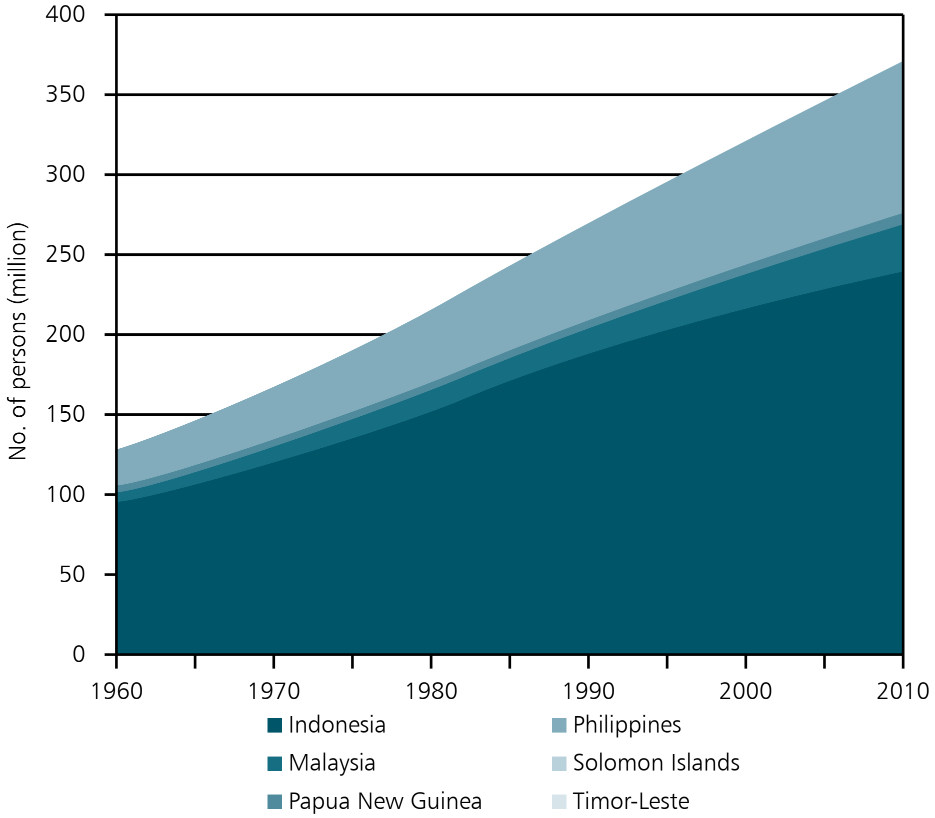
[e] Of which 1,371,676 are municipal fishers and 16,497 are commercial fishing operators. Bureau of Fisheries and Aquatic Resources (BFAR). Fish contribution to the economy, 2009. http://www.bfar.da.gov.ph/pages/aboutus/maintabs/stat-fishcontri.html

[f] Of this number, 278,613 are marine fish farmers, 470,828 are brackishwater fish farmers, and the remainder (the majority) are freshwater fish farmers.

[g] This assumes an average of four members per household for Indonesia, Malaysia, and the Philippines; and five members per household for Papua New Guinea, Solomon Islands, and Timor-Leste.

[h] However, almost all of the population in Solomon Islands are subsistence fishers.

Figure 1 **Population Trends in CT6 Countries, 1960–2010**



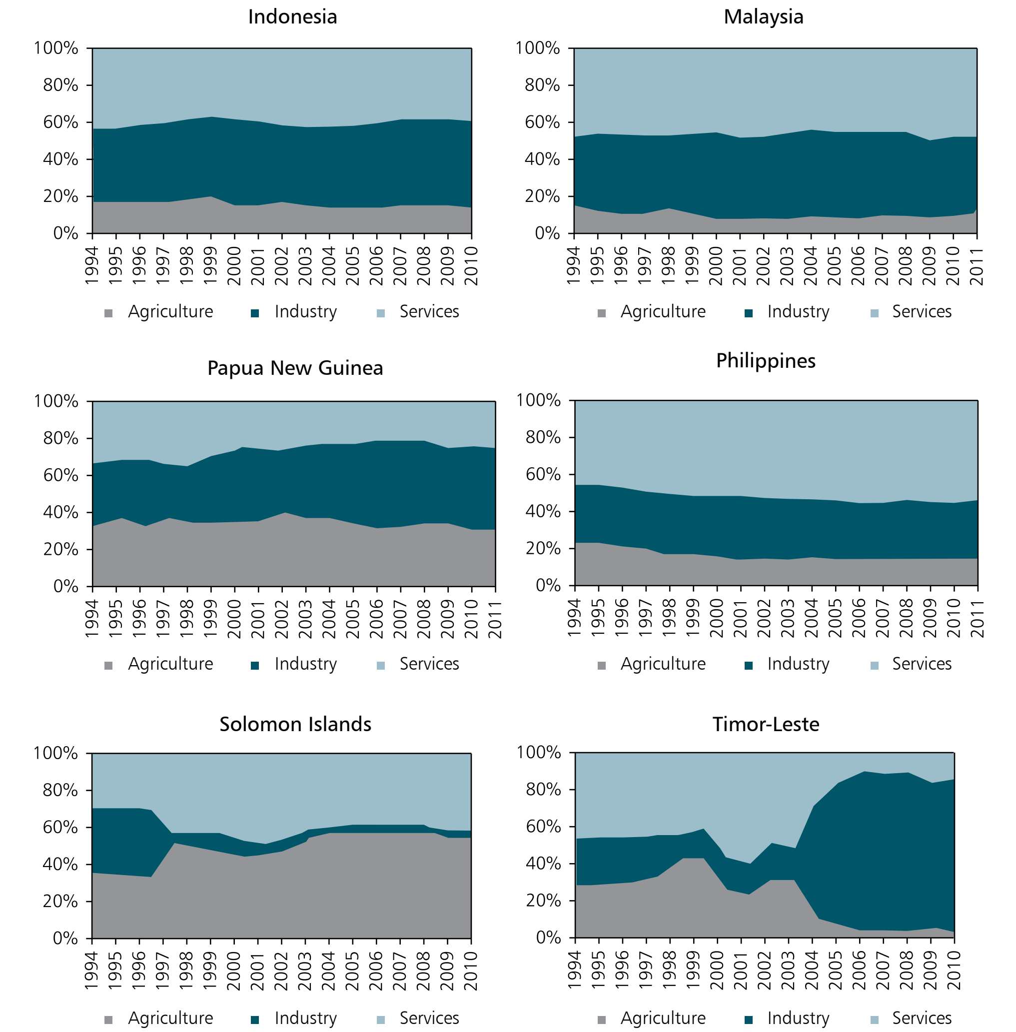
Source: World Bank. Data, Population (Total). http://data.worldbank.org/indicator/SP.POP.TOTL (accessed 25 October 2012).

terms of income, the Asia and Pacific region had sustained the growth trend that started in 2004. In 2011, the region contributed 70% to global gross domestic product (GDP) owing to the presence of huge developed countries such as the People's Republic of China, India, and Japan. Real GDP growth was robust for the CT-Pacific countries, with Timor-Leste growing by more than 10% over a 5-year period, followed by PNG (7.3%) and Solomon Islands (6.8%).[4]

The share of agriculture (including fisheries and aquaculture) in GDP declined in CT-SEA countries (Figure 2), which were dominated by the services and industry sectors. In Solomon Islands, the share of agriculture in GDP increased from 30% in 1994 to more than 50% in 2011, with the services sector contracting severely. The opposite trend was observed in Timor-Leste, where the share of the agriculture sector diminished to one-third of its average level during the 1990s and earlier part of the 2000s. The industry sector, mainly petroleum and accounting for more than 80% of GDP, has buoyed Timor-Leste's economy, and has been used mainly to support the creation of human and physical capital. Agriculture has declined to less than 5% of GDP, giving rise to food security issues. In PNG, the Liquefied Natural Gas Project is expected to

[4] ADB. Statistics and Database. http://www.adb.org/statistics/

Figure 2 Gross Domestic Product Composition in CT6 Countries by Sector



Source: ADB (2012a).

further boost revenues from the industry sector, but increasing income disparity remains due to inability to translate revenues into basic social and physical services.

Malaysia is moving toward joining the ranks of high-income economies. This will increase its purchasing power and demand for wider nutritional options. Malaysia's experience is instructional. While oil palm and rubber are steady contributors to national income, the financial crisis of 1997 saw Malaysia incurring a balance of trade deficit of about $1.8 billion in 2004 (Othman n.d.). The Third National Agricultural Policy (NAP3) (1998–2010) was expected to provide a facelift to the country's agriculture sector and recognize the significant contribution of the fishery sector to the economy. Based on data from the Ministry of Agriculture (Othman n.d.), only fisheries yielded a positive balance of trade compared to livestock and other agricultural commodities. NAP3 and the subsequent National Agri-Food Policy will continue to boost production of the fisheries sector; and ensure its contribution to food security, exports, incomes, and poverty alleviation.

Poverty incidence in PNG, the Philippines, and Solomon Islands was between 20% and 30%. In 2008, it was 41.1% in Timor-Leste, in sharp contrast to Malaysia's 3.8%. In the Pacific, there has been "urbanization of poverty" (ADB 2012b). The previous definition of poverty as equivalent to "hardship" has been replaced by the harsh reality of hunger, destitution, and absolute poverty, as experienced in other developing countries mainly because of population growth, political instability, ineffective governance, and ethnic strife.

Urbanization is also an internal driver and determinant of demand for fish. In 2010, 43% of the Asia and Pacific population lived in urban areas, the second lowest urban proportion of a region in the world. However, since the 1990s, the region's urban proportion has risen by 29%, more than any other region. Rapid economic development generally encourages rural to urban migration, although such push factors as conflicts, disasters, and environmental changes are also contributory factors. Among the CT6 countries, Malaysia has the largest urban population (72%) and PNG has the lowest (12%). The fastest rural to urban migration trends are observed in Solomon Islands and Timor-Leste.

B. Fisheries Production in the Coral Triangle

Fish supply in the Coral Triangle is obtained from two primary sources—capture fisheries and aquaculture.[5] **Capture fisheries** are often classified under two categories based on the size of vessels used and the volume of fish caught per unit effort: (i) large-scale, industrial, or commercial fisheries; and (ii) small-scale or artisanal fisheries.[6] **Large-scale or industrial fisheries** often employ capital-intensive technologies; cover larger areas of fishing ground per vessel; engage salaried crews; and, often but not always, operate in marine waters and the open ocean. **Small-scale or artisanal fisheries** use small craft and traditional fishing gears that are manually operated and labor intensive. Small-scale fishers operate inland, in rivers, or nearshore. When fishing is done primarily to supply food for the household, it is called **subsistence fishery**.

Aquaculture pertains to the farming of aquatic flora and fauna. It is often categorized according to the environment where it is situated—freshwater, brackishwater, or marine. For fish and invertebrate aquaculture, the type of confinement system employed is also used to group production—fishpond, fish pen, or fish cage. Farming of aquatic plants is done without the use of confinement systems.

In 2010, the CT6 countries harvested and produced 19 million tons (t) of aquatic flora and fauna, accounting for 11.3% of the global aquatic flora and fauna produced that year (Table 2). Approximately 13 million t of these were for food (i.e., fish and invertebrates); while the

[5] Time series data on the volume (t) of marine capture fisheries production and the volume (t) and value ($) of aquaculture production for the CT6 countries were extracted from FishStatJ by excluding the following: for capture fisheries (inland fishing areas, aquatic plants, diadromous fishes, freshwater fishes, crocodiles and alligators, freshwater crustaceans, and freshwater mollusks); and aquaculture (freshwater environment, inland waters, freshwater fishes, freshwater crustaceans, and freshwater mollusks). See FAO (2011b). http://www.fao.org/fishery/statistics/software/fishstatj/en

[6] FAO. Fisheries and Aquaculture Department. Types of fisheries. See http://www.fao.org/fishery/topic/12306/en

Table 2 **Aggregate Aquatic Production of CT6 Countries, 2010** (ton)

Production	Environment	Fish	Invertebrates	Aquatic Plants	Total
Aquaculture	Marine	142,599	191,726	5,418,100	5,752,425
	Brackishwater	802,677	546,793	515,581	1,865,051
	Freshwater	1,796,625	1,974	–	1,798,599
Capture Fisheries	Marine	8,292,548	856,644	3,170	9,152,362
	Freshwater	456,233	92,190	–	548,423
Total		11,490,682	1,689,327	5,936,851	19,116,860

Source: FAO (2011b).

remaining 6 million t were aquatic plants, which are high-value products that contribute to the income of aquaculture workers and owners. Excluding aquatic plants, the CT6 countries contributed 9.8% to global food supply from aquatic sources in 2010.[7]

Most fisheries production in CT6 countries comes from marine and brackishwater environment with a production of 13.2 million t of fish and invertebrates in 2010 compared to 2.3 million t from inland fisheries and freshwater aquaculture. Aquatic plants are cultured only in marine and brackishwater environments, and a small proportion is harvested from the wild in marine areas.

In addition to capture fisheries and aquaculture, the CT6 countries import food fish and related commodities from other countries. In 2010, these countries imported an aggregate volume of 802,461 t of fishery commodities.[8] (Fishery trade patterns are discussed in greater detail in Chapter III.)

Overall, fisheries production in CT6 countries continues to grow (Figure 3). Fishes form the bulk of production; and harvests continue to rise at an exponential rate, fuelled primarily by aquaculture. Production of aquatic plants has increased rapidly since 2005. Harvest and culture of aquatic invertebrates are growing at a modest rate of 7% per year.

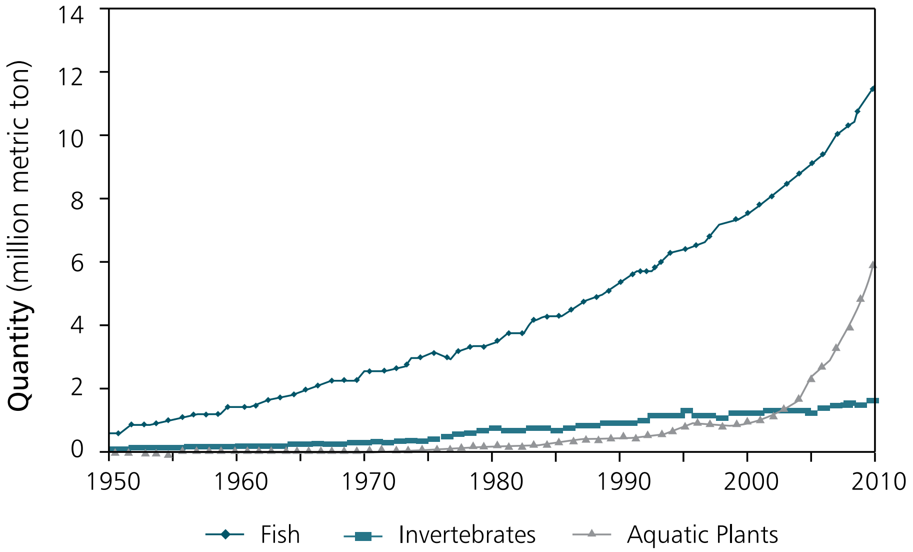
The increase in freshwater resources production in CT6 countries could be attributed to the exponential growth in aquaculture (Figure 4). Since 2005, freshwater aquaculture has grown by a remarkable average of 16% across the CT6 countries. In contrast, freshwater and/or inland capture fisheries have stagnated, with catches of invertebrates significantly declining since the early 1980s.

The continued growth in fisheries and aquaculture production from marine and brackishwater environments in CT6 countries was made possible by the exploitation of a wide variety of fishery resources and the culture of various fauna and flora (Table 3). Large and small pelagic fishes, demersal and reef fishes, and invertebrates are all harvested through capture fisheries; while seaweed, shrimps, and milkfish are the major marine and brackishwater aquaculture commodities in CT6 countries.

7 Global production of fish and invertebrates in 2010 was 134,386,512 t based on FAO (2011b).

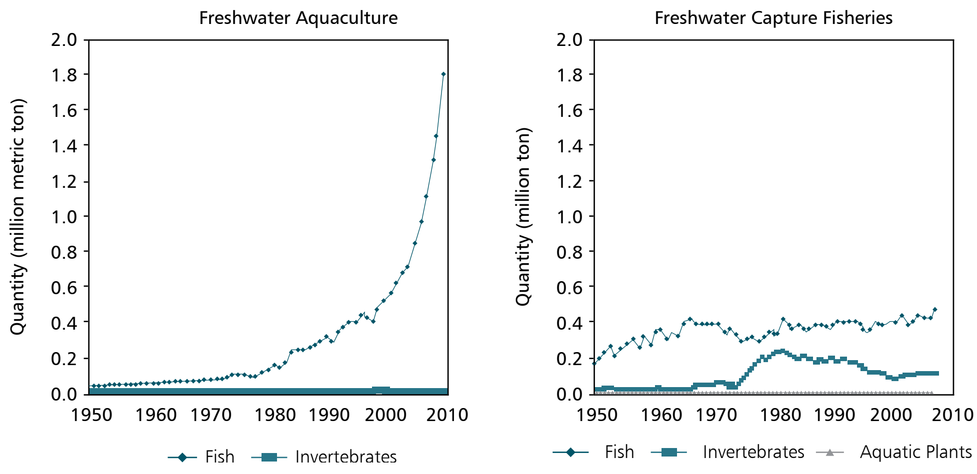
8 Global population data from the World Bank Development Indicators. http://data.worldbank.org/data:catalog/world-development-indicators (accessed 28 February 2013).

Figure 3 **Total Aquatic Resources Production in CT6 Countries, 1950–2010**



Source: FAO (2011b).

Figure 4 **Trend in Aquaculture and Capture Fisheries Production from Freshwater/Inland Environments in CT6 Countries, 1950–2010**



Source: FAO (2011b).

1. Marine Capture Fisheries in the Coral Triangle

Production volumes and trends. In 2010, a total of 9.1 million t of fish and invertebrates were harvested by capture fisheries from the coastal and marine waters of CT6 countries, accounting for 11.8% of global capture fisheries production. Indonesia accounted for 54% and the Philippines for 26% of production (Figure 5), while Timor-Leste had the lowest marine

Table 3 **Major Fishery Resources and Aquaculture Products of CT6 Countries**

Country	Marine Fishery (by volume)	Marine and Brackishwater Aquaculture Products
Indonesia	1. Large pelagics (skipjack [*Katsuwonus pelamis*]), other tunas, billfish, oceanic shark, small tuna) 2. Small pelagics (scad, mackerel, sardinella, trevally, engraulid anchovy) 3. Demersal and coral reef fishes (grouper, snapper, rabbitfish, slipmouth, others) 4. Prawn, shrimp, other crustaceans, others	1. Seaweed 2. Shrimp 3. Milkfish (*Chanos chanos*) 4. Giant gourami 5. Grouper 6. Mud crab
Malaysia[a]	1. Small pelagics: Indian mackerel (*Rastrelliger* spp.), round scad (*Decapterus* spp.), squid (*Loligo* spp.), anchovy (*Stolephorus spp.*), ox-eye scad (*Selar boops*), hardtail scad (*Megalaspis cordyla*), lizard fish, and jewfish 2. Tuna and tuna-like species: *Thunnus spp.*, *Euthynnus affinis*, *Auxis thazard*, *Katsuwonus pelamis* 3. Demersal fishes: threadfin bream (*Nemipterus spp.*, *Pentapodus spp.*) 4. Shrimps	1. Seaweeds 2. Cockles 3. Shrimps/prawns (Hawaiian white shrimp and tiger prawn) 4. Barramundi 5. Mussels
Papua New Guinea	1. Tuna: albacore and yellowfin 2. Shrimps: banana prawn (*Penaeus merguiensis*) 3. Reef fishes: wrasse (*Labridae*), grouper (*Serranidae*), emperor (*Lethrinidae*), bream (*Sparidae*), sea perch and fusilier (*Lutjanidae*), parrot fish (*Scaridae*), sweetlips (*Haemulidae*), butterfly bream and monocle bream (*Nemipteridae*), squirrelfish (*Holocentridae*), drummer (*Kyphosidae*), eel (*Muraenidae*), triggerfish (*Balistidae*), rabbitfish (*Siganidae*), surgeonfish and unicorn fish (*Acanthuridae*), and goatfish (Mullidae) 4. Invertebrates: bêche-de-mer, lobster, trochus, giant clam, crab, octopus, and green snail	Marine and brackishwater aquaculture is not extensive. Some marine aquaculture products are seaweed, giant clam, crocodile, milkfish, mullet, mussel, oyster, and prawn.
Philippines	1. Small pelagics (roundscad (*Decapterus* spp., *Carangidae*]), anchovy (*Stolephorus* spp., *Engraulidae*), sardine (*Sardinella* spp., *Clupeidae*) and mackerel (*Rastrelliger* spp., *Scombridae*); round herring (*Clupeidae*), flying fish (*Exocoetidae*), and halfbeak (*Hemiramphidae*) 2. Tuna and other large pelagic fishes (yellowfin [*Thunnus albacares*]), skipjack (*Katsuwonus pelamis*), Eastern little tuna or kawakawa (Euthynnus affinis), frigate tuna (*Auxis thazard*)) 3. Demersal and reef fishes: slipmouth, spadefish, grouper and catfish; snapper and rabbitfish; marine ornamental fishes 4. Invertebrates: crab (e.g., *Portunus pelagicus*)	1. Seaweeds (mainly *Kappaphycus* and *Eucheuma spp.*) 2. Milkfish (*Chanos chanos*) 3. Shrimp (mainly tiger prawn, Penaeus monodon) 4. Oyster (slipper-cupped oyster [Crassostrea iredalei]) 5. Mussel (green mussel, *Perna viridis*) 6. Live reef fish (e.g., grouper)

continued on next page

Table 3 *continued*

Country	Marine Fishery (by volume)	Marine and Brackishwater Aquaculture Products
Solomon Islands	1. Tuna: skipjack, yellowfin, bigeye, albacore 2. Pelagics: shark, billfish, opah, wahoo, dolphinfish 3. Demersal and reef fishes: snapper (*Lutjanidae*), grouper and rock cod (*Serranidae*), emperor (*Lethrinidae*), mackerel (*Scombridae*), trevally (*Carangidae*) 4. Invertebrates: bêche-de-mer, trochus, green snail, giant clam, crab, and lobster	Priority aquaculture commodities: seaweed; tilapia; sea cucumber; and marine ornamentals, including corals and giant clams
Timor-Leste	Scant information on catch composition but lack of large and motorized fishing vessels limit fishers to catching reef fishes and small pelagics using traditional fishing gears	Brackishwater aquaculture (particularly tiger shrimp and milkfish) was promoted in coastal areas of some districts, including Liquica and Manatuto. Freshwater aquaculture, particularly of common carp (*Cyprinus carpio*), was promoted in Ermera, Aileu, Manufahi, and Viqueque districts, where freshwater fish hatcheries were established. Aquaculture activities virtually collapsed during the conflict period.

[a] Trash fish comprised 20% of total capture fisheries production of Malaysia in 2009.

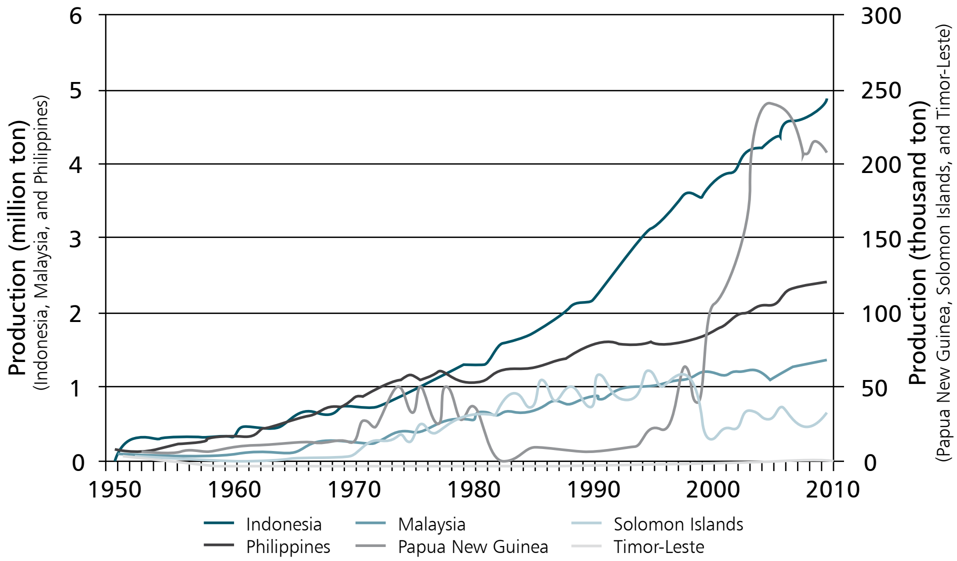
Source: FAO (2010).

capture fisheries production of 3,125 t. While global capture fisheries production appears to have leveled off since 1986 at 80 million t, the capture fisheries production of CT6 countries has continued to rise although the growth rate has slowed down from an average of 4.8% in 1951–1999 to 2.8% in 2000–2009 (Figure 5). Indonesia has led in terms of growth in capture fisheries production, followed by the Philippines, Malaysia, PNG, and Timor-Leste, in that order. FAO time series catch data for Solomon Islands indicate a sharp decline from 1999 to 2000 by as much as two-thirds, attributed to ethnic tensions that began in the 1990s (Pinca et al. 2009). From 2000, capture fisheries production of Solomon Islands has fluctuated at about 30,000 t.

The overall increasing trend in fish capture in CT6 countries is apparent for most taxa of fish and invertebrates (Table 4), although some groups have started to peak or decline in production. Catches of shrimps and prawns appear to have leveled off to 35,000 t since 2002; of tunas, bonitos, and billfishes hovered at 1.9 million t since 2007; and of sharks, rays, and chimeras started to decline in 2004.

Tuna is an important fishery commodity in the Coral Triangle as evidenced by the aggregate catch composition of fisheries in CT6 countries. In 2009, 46% of all tuna catches in Western and Central Pacific, valued at $1.5 billion, came from the national waters of Indonesia, PNG, the Philippines, and Solomon Islands (Table 5). Of this amount, $1.1 billion was retained in CT6 countries (excluding access for foreign fishing fleets in PNG and Solomon Islands). For both PNG and Solomon Islands, tuna catches by foreign fleets were higher than by their respective

Figure 5 **Estimated Marine Capture Fisheries Production in CT6 Countries, 1950–2010**



Note: The secondary vertical axis (right) corresponds to the data for Papua New Guinea (PNG), Solomon Islands, and Timor-Leste. Data for PNG and Solomon Islands exclude catches from foreign-based fleets that, in 2007, contributed 52.8% of the total capture fisheries production of PNG (619,568 t), and 70.1% to that of Solomon Islands (139,892 t).

Sources: FAO (2011b) and Gillett (2009).

national fleets. The Philippines fleet, however, is able to fish in other waters of the Western and Central Pacific as its total catch exceeds those caught in its national waters. Tuna data from the Western and Central Pacific Fisheries Commission (WCPFC) for Solomon Islands indicate a relatively stable annual catch of around 84,000 tons from 1997 to 2009.[9]

Catch composition. Open water pelagic fishes from the families *Scombridae*, *Carangidae*, and *Clupeidae* comprised 53% of the total marine capture fisheries production for CT6 countries in 2009 (Figure 6). A large part of the reported catch is not disaggregated into fish families (i.e., marine fishes not elsewhere included or "nei" made up 11% of capture fisheries production in 2009). Mackerels, especially the short mackerel (*Rastrelliger brachysoma*), Indian mackerel (*Rastrelliger karnagurta*), and tuna (skipjack, frigate, and yellowfin) form the bulk of the catches in CT6 countries, accounting for half of the marine capture fisheries production of Indonesia and the Philippines (SEAFDEC 2012). Of the fish caught in CT6 countries in 2009, 32% or 2.8 million t comprised reef-associated fish and invertebrate families (Figure 6).[10] Of these reef-associated fishes and invertebrates, 47% were from the family *Carangidae*, composed of various scads, jacks, and trevallies that are known to inhabit coral reefs, mangroves, and seagrass or forage in these areas,

[9] Pacific Islands Forum Fisheries Agency. WCPFC Area Catch Value Estimates. See http://www.ffa.int/catch_value

[10] FAO landing data were categorized according to source of ecosystem as per the method of Newton et al. (2007). The list of FAO landing groups and corresponding habitat and/or ecosystem category used for this analysis is in the appendix.

Table 4 Time Series Trends for Target Species of Marine Capture Fisheries in CT6 Countries

ISSCAAP Group Species	Indonesia	Malaysia	Papua New Guinea	Philippines	Solomon Islands	Timor-Leste	Coral Triangle	Coral Triangle, 2009 (ton)
Marine Fishes								
Flounders, halibuts, soles								36,741
Herrings, sardines, anchovies								1,192,838
Sharks, rays, chimeras								116,323
Lobsters, spiny-rock lobsters								12,673
Squids, cuttlefishes, octopuses								249,605
Tunas, bonitos, billfishes								1,908,989
Turtles								241
Marine fishes not identified								934,018
Miscellaneous coastal fishes								1,420,212
Miscellaneous demersal fishes								108,674
Miscellaneous pelagic fishes								2,158,964
Marine Invertebrates								
Abalones, winkles, conchs								382
Clams, cockles, arkshells								93,922
Corals								4,000
Crabs, sea spider								112,734
Sea urchin and other echinoderm								5,338
Mussels								549
Oysters								418
Pearls, mother-of-pearls, shells								3,889
Scallops, pectens								1,983
Shrimps, prawns								364,894
Sponges								6
Miscellaneous aquatic invertebrates								6,640
Miscellaneous marine crustaceans								5,608
Miscellaneous marine mollusks								3,060

Source: Based on FAO International Standard Statistical Classification of Aquatic Animals and Plants (ISSCAAP) Group Species categories.

Table 5 Tuna Catches in Western and Central Pacific, 2009

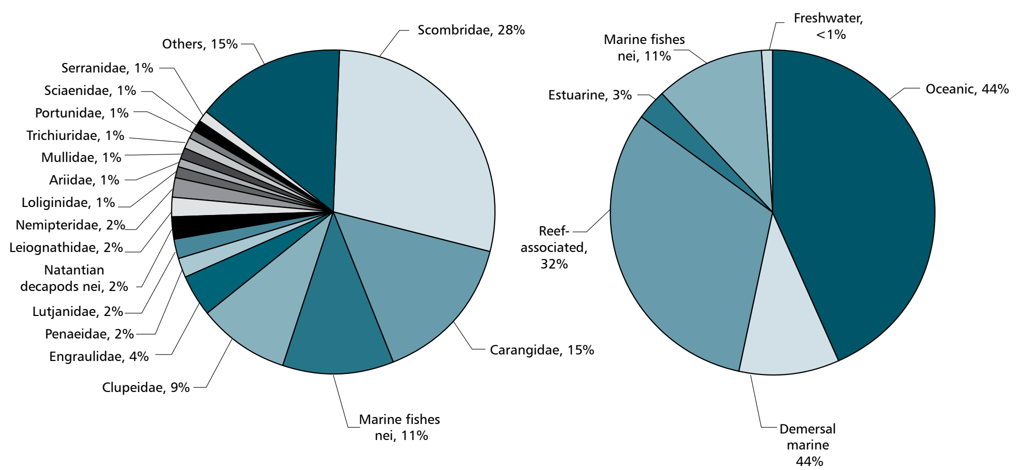
Area	International Fleets Volume (t)	International Fleets Value ($ million)	National Fleets Volume (t)	National Fleets Value ($ million)
Others[a]	773,775	1,337	1,588,521	3,022
International Waters	563,211	1,341		
National Waters in Coral Triangle Countries	1,126,670	1,508	875,135	1,164
Indonesia	319,029	470	316,299	463
Papua New Guinea	438,730	557	212,906	274
Philippines	270,941	360	328,047	405
Solomon Islands	97,969	121	17,883	22
Total	2,463,656	4,186	2,463,656	4,186

t = ton.

[a] Others include the Fisheries Forum Agency (FFA) members: Australia; the Cook Islands; Fiji; Kiribati; the Marshall Islands; the Federated States of Micronesia; Nauru; New Zealand; Niue; Palau; Samoa; Tokelau; Tonga; Tuvalu; Vanuatu; and other economies fishing for tuna in the Western and Central Pacific: American Samoa, French Polynesia, Japan, New Caledonia, Pitcairn, Taipei,China, the United States and its territories (excluding American Samoa), and Wallis and Futuna.

Source: Western and Central Pacific Fisheries Commission. Area Catch Value Estimates. http://www.ffa.int/catch_value

Figure 6 Aggregate Marine Fish Catch Composition in CT6 Countries, 2009



nei = not elsewhere included.

Notes: Left: Using Aquatic Sciences and Fisheries Information System (ASFIS) family classification; Right: Based on ecosystem association of catches. Ecosystem category per species group can be found in the appendix.

Source: FAO (2011b).

as identified in the online fish database, FishBase.[11] The total volume of reef-associated fishes and invertebrates would most likely increase considerably if subsistence fisheries were taken into account and the "nei" category is further disaggregated in landing reports and statistics.

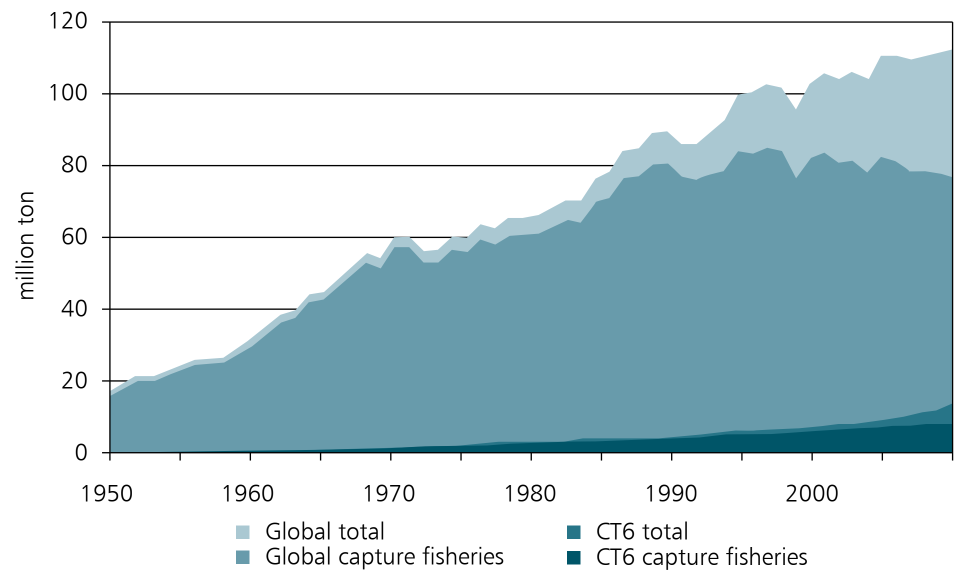
[11] WorldFish Center. http://www.fishbase.org/

One of the unique features of the fisheries of CT6 countries is the diversity of marine fishery resources that are extracted, consumed locally, processed, and exported. More than 2,500 species of reef-associated fish can be found in the Coral Triangle, a large number of which are exploited for sale or subsistence. Reef-, mangrove-, and seagrass-associated fishes are targeted by subsistence and small-scale fishers to augment domestic food supply. Invertebrates such as sea cucumbers, sea urchins, and corals, are important export commodities. More and more, countries are exploiting offshore resources, primarily large pelagic fish, such as tuna, although deep-sea fishery resources remain one of the few untouched marine resources in most Coral Triangle countries, limited primarily by technological capability (Barut et al. 2004).

Foreign-based fleet catches. Reported catches in FAO data for PNG and Solomon Islands are underestimates since these do not include catches by foreign-based fleets. Gillett (2009) estimated that in 2007, catches by foreign-based fishing fleets for PNG added 327,47 t, equivalent to 112% of total domestic marine catches; and for Solomon Islands added 98,023 t, equivalent to 234% of total domestic marine catches. Using the same proportions, the 2010 catches from PNG would be at least 447,907 t and 117,558 t from Solomon Islands, bringing the total marine capture fisheries production for the Coral Triangle to 9.3 million t.

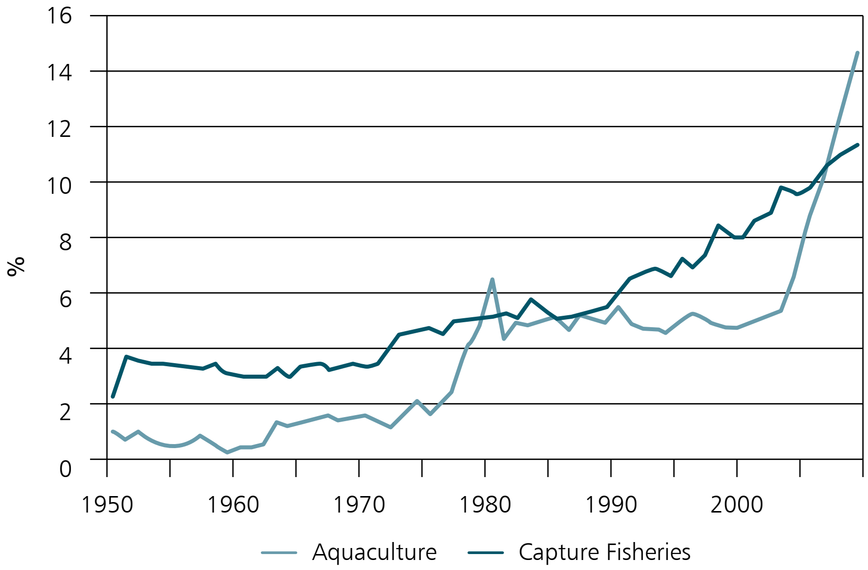
Contribution of marine capture fisheries to global fish production. Based on the FAO FishStatJ dataset (FAO 2011b), the contribution of CT6 countries to global fish production has been increasing since 1950, with an annual growth rate of 5.1% from 1953 to 2003 and 7.1% from 2004 to 2009 (Figures 7 and 8). In 2009, the CT6 countries contributed 12.4% (13.8 million t) to global marine fisheries production. Using FAO data, capture fisheries from CT6 countries accounted for 11% (8.7 million t) of global catches while aquaculture production

Figure 7 Global and CT6 Countries Marine Fisheries Production, 1950–2009



Source: FAO (2011b).

Figure 8 **Percentage Contribution of CT6 Countries to Global Fish Production, 1950–2009**



Source: FAO (2011b).

contributed 14% (5.1 million t) to global aquaculture production. These production values are most likely underestimates because illegal, unreported, and unregulated (IUU) fishing has not been fully included in statistics. Catches of foreign-based fishing fleets are also not included in the CT6 fish production statistics.

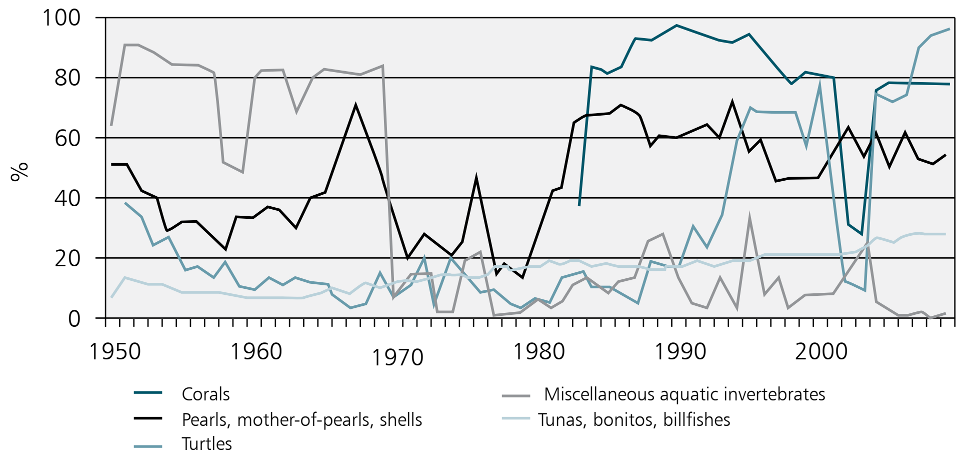
Based on FAO statistics, the major contribution of CT6 countries to global fish production consists of corals; turtles; pearls, mother-of-pearls, and shells; and tunas, bonitos, and billfishes (Figure 9). Coral harvests from CT6 countries amounted to 4,000 t, accounting for 80% of reported global harvests of corals based on the FAO dataset for 2009. Turtle catches by CT6 countries have been rising; and, in 2009, more than 90% of 248 t of turtles reported by FAO came from CT6 countries.[12] These countries also produced 55% of 7,753 t of global production, based on the FAO International Standard Statistical Classification of Aquatic Animals and Plants species group of pearls, mother-of-pearls, and shells. More importantly, at least 29% or 1.9 million t of the global production of tunas, bonitos, and billfishes in 2008 came from CT6 countries.

Marine and Brackishwater Aquaculture in the Coral Triangle

Production volumes and trends. In 2010, production from marine and brackishwater aquaculture systems in CT6 countries was 5.7 million t of fishes, invertebrates, and plants, contributing 17% to global fish production from similar culture systems (Figure 10). Of this total production, 95% came from Indonesia and the Philippines.

[12] Reporting bias is not discounted as a plausible explanation for the high percentage contribution of CT6 countries for particular species, especially corals and turtles.

Figure 9 **Fishery Resources of CT6 Countries, 1950–2009**
(more than 20% of global supply)



Note: CT6 contribution to global production by the FAO International Standard Statistical Classification of Aquatic Animals and Plants species group; and for species wherein the CT6 countries contribute more than 20%.
Source: FAO (2011b).

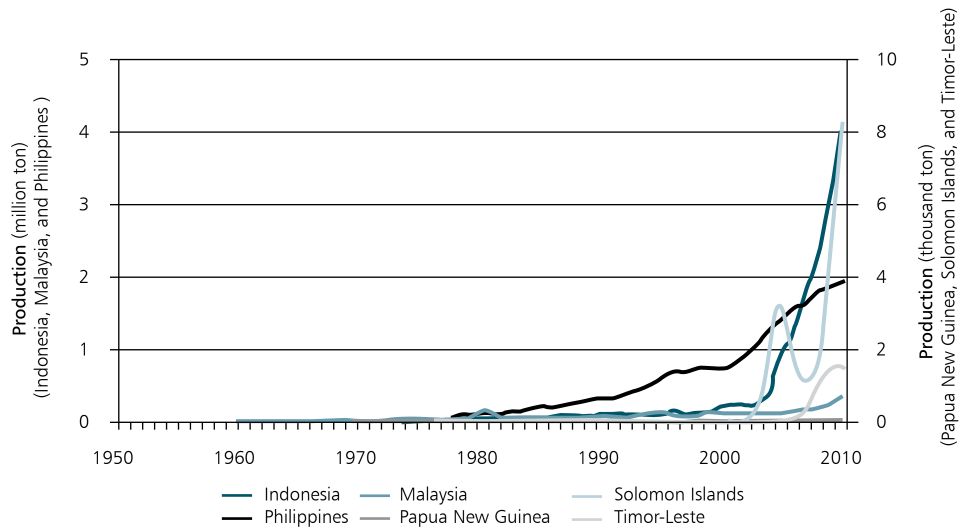
Marine and brackishwater aquaculture production has been increasing, led by Indonesia, where production has expanded at a remarkable rate of 400,000 t/year on average (Figure 10). From 2003 to 2010, Indonesia's brackishwater aquaculture and mariculture increased 14 times from 239,225 t to 3,512,271 t, surpassing the Philippines' production since 2008. The other CT6 countries have shown a slower growth in aquaculture production. For example, Malaysia's marine and brackishwater aquaculture production grew by 24,000 t/year, compared with the Philippines' production of 112,000 t/year. Mariculture in the other CT6 countries is still in the development stage,[13] although FAO data include some mariculture production in Solomon Islands and Timor-Leste but none in PNG.

Aquaculture commodities. Seaweed comprises the bulk (95%) of marine and brackishwater aquaculture production in CT6 countries, with the rest consisting of milkfish, mussels, and oysters (Table 6). Grow-out of live reef food fish, such as groupers, is an expanding industry, particularly in Southeast Asia, as demand for these commodities by Chinese consumers has been on the rise (Fabinyi et al. 2012). However, data on production and trade of these commodities remain intractable.

Contribution of marine and brackishwater aquaculture to global fish production. Indonesia and the Philippines were among the world's top 10 aquaculture producers by volume in 2010. Indonesia accounted for 3.8% of the 59.9 million t of global aquaculture production, including freshwater aquaculture (FAO 2012); while the Philippines accounted for 1.2%. Excluding freshwater aquaculture, the CT6 countries contributed 17% of global production from marine and brackishwater aquaculture in 2009. If production from the

[13] See also Chapter III.

Figure 10 **Estimated Marine and Brackishwater Aquaculture Production of CT6 Countries,1950–2010**



Source: FAO (2011b).

People's Republic of China is excluded, the proportion from CT6 countries would be 45% of world aquaculture production.

The aquaculture industry produces 96% of pearls, mother-of-pearls, and shells; 66% of the world's red seaweed (*Eucheuma cottonii*); 25% of lobsters and spiny-rock lobsters; and 20% of green seaweed (e.g., *Caulerpa* species). Although about two-thirds (63%) of total marine fisheries production in CT6 countries come from capture fisheries, their aquaculture production could surpass capture fisheries production by 2017, based on 24.2% annual increase in aquaculture from 2004 to 2009 compared with 2% annual increase in capture fisheries production during the same period.

Prices of fisheries products from fish capture and aquaculture were derived from the volume and value of production in CT6 countries (Tables 7–9). For capture fisheries, the derived prices clearly support a Southeast Asia or Pacific grouping based on the convergence of prices. Fishes are generally more expensive by at least 50% in the Pacific countries than those in Southeast Asia. In contrast, the derived prices from aquaculture are more dispersed, with Indonesia and the Philippines registering the lowest prices, possibly because seaweed comprises the bulk of their produce from aquaculture. Malaysia's derived price is almost three times that of the Philippines, which can be attributed to the higher value of the species cultured.

Table 6 **Composition of Marine and Brackishwater Aquaculture Production in CT6 Countries**

Species (ISSCAAP group)	Indonesia	Malaysia	Papua New Guinea	Philippines	Solomon Islands	Timor Leste	CT6	Global
Marine Fishes								
Miscellaneous diadromous fishes	2,622	20,022		87,199			109,843	128,554
Marine fishes not identified	43,690	8,482		162			52,334	393,591
Miscellaneous coastal fishes	7,657	12,430		1,224			21,311	708,989
Miscellaneous pelagic fishes				38			38	225,574
Other marine fishes								2,179,347
Crustaceans/Invertebrates								
Clams, cockles, arkshells		78,025					78,025	4,885,179
Pearls, mother-of-pearls, shells	58,079						58,079	60,240
Mussels		10,529		20,877			31,406	1,812,371
Oysters		812		22,525			23,337	4,488,544
Sea urchin and other echinoderm	476						476	137,155
Lobsters, spiny-rock lobsters	311			91			402	1,611
Crabs, sea spiders		8		1			9	92,657
Other crustaceans/invertebrates								3,082,673
Aquatic Plants								
Red seaweed	3,915,017	207,892		1,796,963	8,000	1,500	5,929,372	8,973,565
Green seaweed				4,309			4,309	21,384
Other aquatic plants								9,909,953
Total	**4,027,852**	**338,200**		**1,933,389**	**8,000**	**1,500**	**6,308,941**	**37,101,388**

ISSCAAP = International Standard Statistical Classification of Aquatic Animals and Plants.

Source: FAO.

Table 7 Volume and Value of Capture Fisheries Production in CT6 Countries, 2007

Country	Volume (t) (FAO)[a]	Volume (t) (various sources)	Value ($)	Value/ton ($)
Indonesia	4,630,588	4,734,280[b]	4,931,010,735[b]	1,042
Malaysia	1,355,956	1,381,423[c]	1,466,371,836[c]	1,061
Papua New Guinea	234,368	619,568[d]	811,730,952[d]	1,310
Philippines	2,332,788	2,328,200[e]	2,454,965,353[e]	1,054
Solomon Islands	31,322	139,892[d]	210,079,814[d]	1,502
Timor-Leste	2,912	2,909[f]	5,817,600[f]	2,000[g]
Total	**8,587,934**	**9,206,272**	**9,879,976,290**	**(Mean) 1,328**

FAO = Food and Agriculture Organization of the United Nations, t = ton.

[a] Data from FAO FishStatJ (FAO 2011b).

[b] From Database of Existing Condition on Indonesian Marine and Fisheries. http://www.kkp.go.id/upload/jica/web01/index.html (accessed 25 October 2012).

[c] From Status of the Fisheries Sector in Malaysia. 2007. http://www.dof.gov.my/224

[d] Gillett (2009).

[e] This includes commercial and municipal (marine) fisheries production. http://www.bfar.da.gov.ph/pages/statistics/table1.htm#table-2 (accessed 25 October 2012).

[f] Kalis (2010).

[g] This does not reflect a weighted fish catch value and appears to be a default conversion factor used for calculating the value of the capture fisheries production for Timor-Leste by Kalis (2010).

Table 8 Production from and Value of Marine and Brackishwater Aquaculture in CT6 Countries, 2007

Country	Volume (t) (FAO)[a]	Volume (t) (Various Sources)	Value ($)	Value/ton ($)
Indonesia	1,752,435	1,509,528[b]	441,959,865[b]	293
Malaysia	152,768	198,450[c]	303,732,907[c]	1,531
Papua New Guinea	1	200[d]	690,036[d]	3,450
Philippines	1,626,193	1,880,100[e]	980,166,358[f]	521
Solomon Islands	1,081	165[d]	33,831[d]	205
Timor-Leste[g]	370	...	...	...
Total	**3,532,848**	**3,588,443**	**1,726,582,996**	**(Mean) 1,200**

... = data not available, FAO = Food and Agriculture Organization of the United Nations, t = ton.

[a] Data from *FAO* FishStatJ software (FAO 2011b).

[b] From Database of Existing Condition on Indonesian Marine and Fisheries. http://www.kkp.go.id/upload/jica/ web01/index.html (accessed 25 October 2012).

[c] From Status of the Fisheries Sector in Malaysia. 2007. http://www.dof.gov.my/224

[d] Gillett (2009). For Solomon Islands, the reported tonnage and value ($) are for seaweed only. Other aquaculture products are recorded as number of pieces and not by volume (i.e., 1,202 pieces of post-larvae capture and/or culture valued at SI$7,554 and 7,000 pieces of corals valued at SI$56,000).

[e] This includes brackishwater fishpond, marine fish cage and/or fishpen and seaweed. http://www.bfar.da.gov.ph/pages/statistics/table1.htm#table-1 (accessed 25 October 2012).

[f] This includes brackishwater fishpond, marine fish cage and/or fishpen and seaweed. http://www.bfar.da.gov.ph/pages/statistics/table3 (accessed 25 October 2012).

[g] Although Timor-Leste's Ministry of Agriculture and Fisheries–National Directorate of Fisheries and Aquaculture (2012) reported the value of seaweed amounting to $19,130 in 2009, no volume was reported.

Table 9 Currency Conversion Rates, 2007

Currency	$1.00 Equivalent
Indonesian rupiah (Rp)	9,131.12
Malaysian ringgit (RM)	3.44
Papua New Guinea kina (K)	2.90
Philippine peso (P)	46.09
Solomon Islands dollar (SI$)	7.30

Source: See the period average at http://www.oanda.com/currency/historical-rates

C. Fisheries Values

1. Contribution of Fisheries to the National Economy

The contribution of fisheries and aquaculture to the national economy of CT6 countries—in terms of the percentage of value added to GDP, percentage of export value of fishery products to total export value, and employment—varies across the countries. Fisheries and aquaculture accounted for 1.2%–6.8% of GDP in 2007 (Table 10).

Table 10 Contribution of Fisheries to the National Economies of CT6 Countries

Country	% of Fisheries to GDP (2007)	% of Export Value of All Fishery Products	Number of Employment	
			Fisheries	Aquaculture
Indonesia	2.4[a]	1.9[b]	2,169,279[c]	749,441[c]
Malaysia	1.2[d]	0.4[e]	99,617[f]	...
Papua New Guinea	3.4[g]	10.0[g]	5,114	...
Philippines	2.2[h]	0.9[i]	1,388,173[j]	226,195[j]
Solomon Islands	6.8[g]	12.0[g]	30,000	...
Timor-Leste	...	...	5,718	...

... = data not available, GDP = gross domestic product.

Sources:

[a] From Database of Existing Condition on Indonesian Marine and Fisheries. http://www.kkp.go.id/upload/jica/web01/index.html (accessed 25 October 2012).

[b] http://www.kemendag.go.id/statistik_perkembangan_impor_nonmigas_%28komoditi%29/ (accessed 25 October 2012).

[c] Data for 2009 from the *Indonesian Fisheries Book* (MMAF–JICA 2011).

[d] From Status of the Fisheries Sector in Malaysia. 2007. http://www.dof.gov.my/224

[e] Obtained by dividing the total fish export value for Malaysia for 2007 by the total export value of Malaysian commodities (2007). http://www.fao.org/fishery/statistics/global-commodities-production/query/en; http://www.statistics.gov.my/portal/download_Economics/files/DATA_SERIES/2011/pdf/03Perdagangan_luar_negeri.pdf (accessed 25 October 2012).

[f] DOF (2009).

[g] Gillett (2009).

[h] *Philippine Fisheries Profile. 2007*.

[i] Department of Trade and Industry. http://dti.gov.ph/uploads/DownloadableForms/BETP%20Stats_Exports%20by520Product%20Grouping%20FY%202006%20to%202011_25may2012.pdf (accessed 25 October 2012).

[j] From DA-BFAR (2007). Aquaculture employment includes those working in fishponds.

While the numbers reflect official statistics, this report is cognizant of issues in the estimation of fisheries contribution to GDP, particularly in the Pacific island countries (Gillett and Lightfoot 2001). The system of generating national accounts; the difficulty in estimating fisheries production, particularly for the subsistence fisheries; and the lack of coordination between fisheries and statistics and/or planning agencies affect the credibility of the numbers. Gillett and Lightfoot (2001) reestimated fisheries contribution to GDP for PNG, resulting in more than double the official number, i.e., from 0.6% to 1.4% of GDP. They also provided an estimate of fisheries contribution to GDP for Solomon Islands (12% in 1999), which had no official estimate at the time.

In general, official estimates of GDP contribution from fisheries do not include indirect and induced impacts of marine capture fisheries on the national economy (e.g., boat building, domestic and international transport, fishing gear production, and others). Accounting for indirect and induced effects, the contribution of the fisheries sector to the national economies of CT6 countries could double or triple the current estimates, which use only the value of landings at first sale (Dyck and Sumaila 2010). The contribution of the subsistence sector to the national economy is also largely ignored.

Since the 1960s, the percent contribution of agriculture (including fisheries) to GDP of Indonesia, Malaysia, and the Philippines has been declining to an almost stable level of 10%–15% (Figure 11). It has remained high for PNG and Solomon Islands at 35%–40% of GDP.

Fisheries and aquaculture employ at least 4.6 million citizens of the CT6 countries, representing 1.3% of their aggregate population or 2.0% of total persons employed in 2009.[14] Assuming an average household size of four, the total number of people directly dependent on fisheries for livelihood in the Coral Triangle is 18.4 million or 5% of the aggregate population of CT6 countries in 2009.

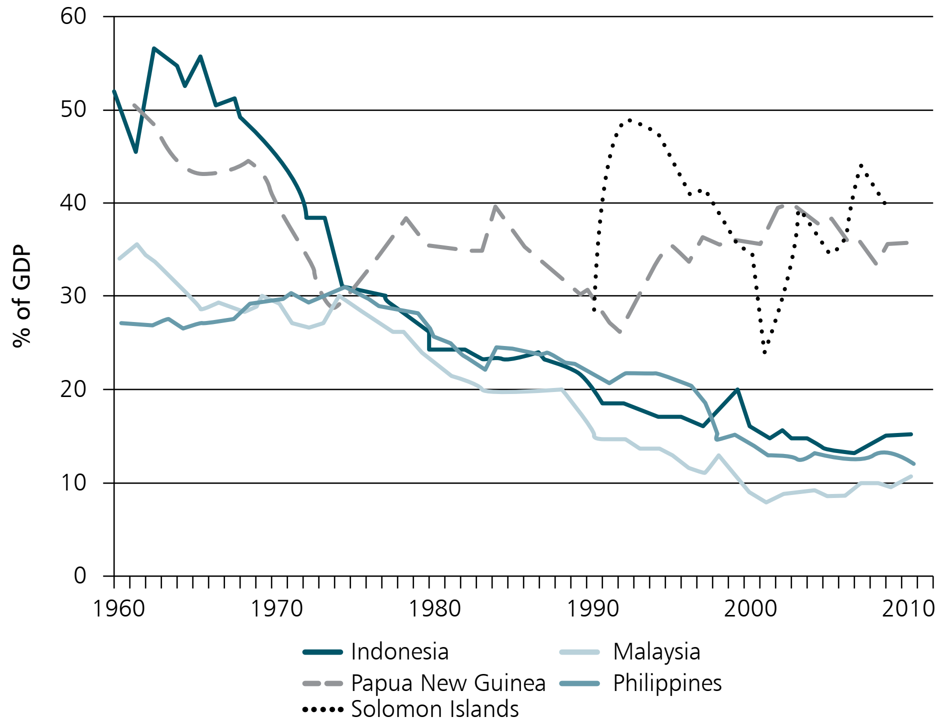
2. Contribution of Coral Reefs to Fisheries

In the Coral Triangle, natural coastal habitats line over 132,800 km of the coastline; and are extremely valuable in providing various ecosystem functions, goods, and services (Hoegh-Guldberg et al. 2009). Coral reefs and their associated ecosystems are critical in providing food and livelihood to more than 120 million people in the region living within 10 km of the coastline. Hoegh-Guldberg et al. (2009) estimated the value of commercial fisheries at over $3 billion per year in CT6 countries. This value is less than one-third of their actual capture fisheries production value.

In 2007, the CT6 marine capture fisheries were valued at $9.9 billion, while marine and brackishwater aquaculture production was valued at $1.7 billion. Wilkinson (2008) estimated the total value of coral reef ecosystems in the Coral Triangle at $2.3 billion per year, including fisheries, tourism, and education functions. Based on the collated fisheries data, the value of coral reefs to capture fisheries production in the Coral Triangle was estimated by (i) identifying reef-associated fish catches in the FAO dataset for 2007 (FAO 2011b), (ii) determining the percentage

[14] Total population of the CT6 countries in 2009 was 365.4 million and 62.1% of these were employed (15 years and older). Data are from the World Bank *Employment to Population Ratio*. http://data.worldbank.org/indicator/SL.EMP. TOTL.SP.ZS (accessed 28 February 2013) while population data are from http://data.worldbank.org/indicator/SP.POP.TOTL

Figure 11 **Value-Added Contribution of Agriculture to Gross Domestic Product in CT6 Countries, 1960–2010**



GDP = gross domestic product.
Source: World Bank (n.d.[a]).

composition of reef-associated fishes in the total capture fisheries production for each country, and (iii) multiplying the reported total value of capture fisheries (Table 7) by these percentages using a conversion factor for the relative value of reef-associated fishes to pelagic fishes (Table 11).

The FAO marine capture fisheries landing statistics were categorized according to source ecosystem (coral reef, demersal, ocean, freshwater, and estuarine) following the work of Newton et al. (2007), and expanded to categorize the source ecosystem for taxa not included in their study. The latter was identified based on their general environment and biology from FishBase (Froese and Pauly 2013). Reef-associated fishes were defined as those living predominantly on or near coral reef ecosystems and deriving energy from coral reefs and associated habitats for the major part of their lifespan (Newton et al. 2007; supplementary material).

The percentage of reef-associated fishes in overall capture fisheries production varied across the CT6 countries (Table 11). In the CT-SEA countries, reef-associated fishes comprised about 30% of marine capture fisheries production. In the CT-Pacific countries, it is only in Solomon Islands where reef-associated fishes are reported in FAO landings after the "marine fishes nei" group was interpreted as reef-derived (Newton et al. 2007). However, the dominance of tuna in CT-Pacific marine fish catches means that the contribution of reefs to capture fisheries production is most likely proportionately smaller than in CT-SEA. In all the countries, the contribution

Table 11 **Value of Fisheries Attributed to Coral Reefs in CT6 Countries, 2007**

Country	Volume of Reef-Associated Fish in Production, 2007 (%)	Value of Capture Fisheries ($)	Value of Fisheries from Coral Reef-Associated Species ($)
Indonesia	31	4,931,010,735	1,528,613,328
Malaysia	30	1,466,371,836	439,911,551
Papua New Guinea	1[a]	811,730,952	8,117,310
Philippines	38	2,454,965,353	932,886,834
Solomon Islands	32[a]	210,079,814	67,225,540
Timor-Leste	0.4	5,817,600	23,270
Coral Triangle		9,879,976,290	2,976,777,833

[a] Following Newton et al. (2007), "marine fishes nei" for Papua New Guinea (0.89% in 2007) and Solomon Islands (31.93% in 2007) were also categorized as reef-derived for this study.

Source: Based on catch composition as reported for 2007 in the FAO FishStatJ software (FAO 2011b).

of subsistence fisheries that are known to exploit primarily coastal fishes could increase the percentage contribution of reef-associated fishes to the total fish production of CT6 countries. Unfortunately, information on CT6 catches of subsistence fisheries and exploitation rates is limited to studies in small fishing communities, and not integrated in most national statistical sampling methods; hence, insufficient for scaling-up to national statistics.

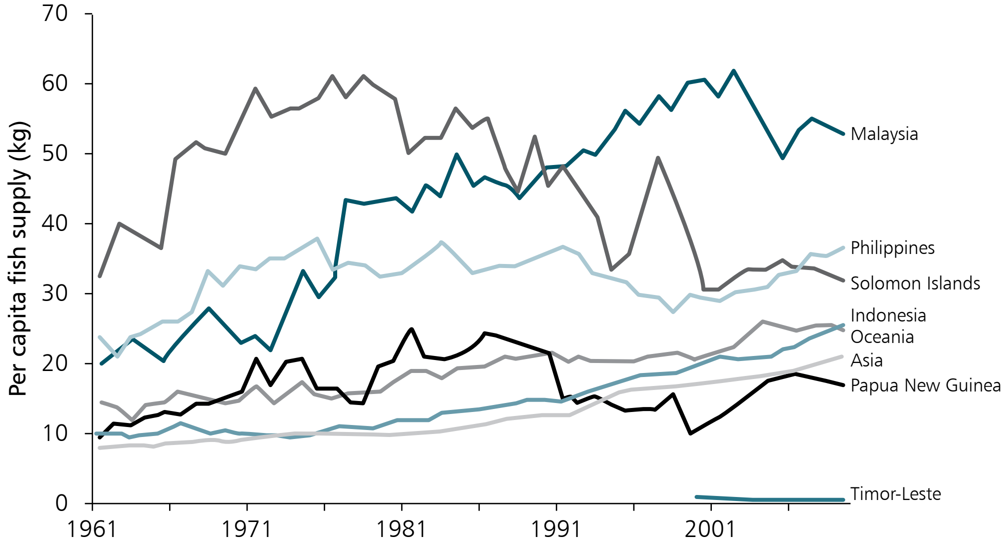
The value of reef-associated fisheries was derived by multiplying the percentage of reef-associated catches per country with the total marine capture fisheries value per country in 2007 (Table 11). Reef-associated fishes in CT6 countries are valued at $3.0 billion, or 30% of the total capture fisheries value in the region. Tuna have been known to feed on reef-associated fishes; and are, thus, also dependent on the presence and quality of coral reef ecosystems. Allain et al. (2012) observed that albacore (*Thunnus alalunga*) and yellowfin tuna (*Thunnus albacares*) frequently consume reef prey, accounting for 10%–30% of their diet depending on their size. Assuming a conservative 10% multiplier to account for the reef-associated prey consumption of tuna, the value of coral reef ecosystem to tuna is estimated to be $150 million for CT6 countries (based on values in Table 5), bringing the total value of coral reefs to fisheries to $3.2 billion in 2007.

3. Dependence on Fish and Food Consumption

Fish and aquatic invertebrates are important protein sources for most countries in Asia and the Pacific. Per capita fish supply has been increasing since 1961 in Malaysia, the Philippines, and Indonesia; and was above the average values for Asia in 2009 (Figure 12). Malaysia showed the fastest rate of increase, followed by the Philippines and Indonesia. In the Pacific, it is only in Solomon Islands where fish supply per capita was at par with the average for Oceania. Per capita fish supply in that country increased from 1961 to the mid-1970s, but started to decline thereafter. Recent estimates for Solomon Islands reveal per capita fish supply similar to that in the early 1960s. The values for PNG and Timor-Leste were below the average for Oceania. PNG's per capita fish supply has fluctuated between 10 kg and 20 kg since the 1960s.

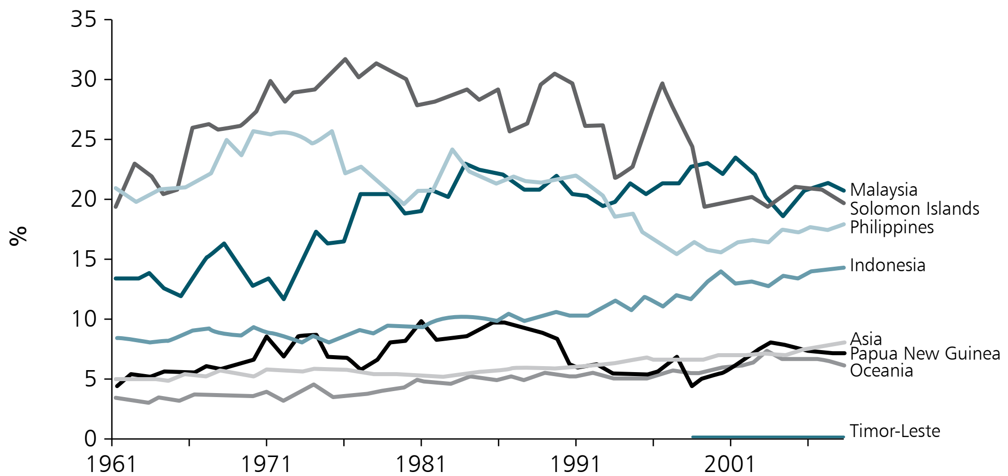
Following the trend in per capita fish supply in Indonesia and Malaysia, the importance of fish as a protein source has also been increasing in both countries (Figure 13). In contrast,

Figure 12 **Per Capita Fish Supply in CT6 Countries, Asia, and Oceania, 1961–2009**



kg = kilogram.
Source: Laurenti (2012).

Figure 13 **Proportion of Fish to Total Protein Provision in CT6 Countries, 1961–2009**



Source: Laurenti (2012).

the relative contribution of fish to protein consumption has been declining in the Philippines, despite the increasing per capita fish supply. The pattern of fish contribution to total protein consumption in PNG and Solomon Islands is similar to the pattern observed for their per capita fish supply, which is indicative of the population's direct consumption of fish.

D. Status of Fishery Resources

The increasing trends in production for both marine capture fisheries and aquaculture can be misleading in that fishing in CT6 countries is sustainable and well within carrying capacity limits. The true state of fisheries in CT6 countries is obscured by the paucity of time series data on fishing and production costs; and the level of effort put into the capture and culture of fish, invertebrates, and aquatic plants.

Available information on several fish stocks and well-studied fisheries offers insights on the status of fishery resources in the region. Maximum sustainable yield (MSY) estimates for some of the high-value fish catches in CT6 countries serve as basis for regulating extraction rates (Lymer et al. 2010). Stock assessments, such as those done by the National Stock Assessment Program (NSAP) in the Philippines, underscore the exploitation status of broad resource categories. Trophic and size-structure analyses reveal the ecological and biological impacts of intensive fishing as pointed out by Geronimo and Aliño (2009) and by the Marine Trophic Index (SAUP 2012). Observed and documented ecosystem changes serve as telltale signs of resource exploitation, reaching tipping points that could change the nearshore and shallow-water seascape dramatically.

An FAO report on the status of world marine fishery resources concluded that the majority of fish stocks in Indonesia, Malaysia, and the Philippines are considered to be at least fully exploited (FAO 2011a). MSY estimates compiled by Lymer et al. (2010) indicate that most of the countries are nearing, if not beyond, critical thresholds for many fish stocks (Table 12).

In Indonesia, catch per unit effort substantially decreased in 1990–2007 in bottom trawling, purse seining, and gillnetting. In the Philippines, the per capita supply of round scad, dubbed "the poor man's fish," declined from 7.2 grams/person/day in 1999 to 4.4 grams/person/day in 2011.[15]

1. Demersal Fisheries

Demersal finfish fisheries of CT6 countries are mostly fully exploited or overexploited. The National Commission on Stock Assessment in Indonesia has reported overfishing of demersal fishes in 5 out of 11 fisheries management areas; only one fisheries management area has been categorized with moderate exploitation (MMAF–JICA 2011). Scientific surveys conducted in Peninsular Malaysia and Sarawak during 1972–1998 indicate widespread overexploitation and depletion of fishery resources in those areas (Ahmad et al. 2003a, 2003b). The Philippines' demersal finfish resources experienced steep declines of up to 64% between the 1940s and 1990s (Stobutzki et al. 2006). The status of demersal and non-tuna fishery stocks in the Coral Triangle Pacific countries is unknown, but it is presumed to be in poor condition (CEA 2012).

15 Bureau of Agricultural Statistics. Fisheries Supply Utilization Accounts. http://countrystat.bas.gov.ph/?cont=10&pageid=1&ma=I70FCSUA (accessed 28 February 2013).

Table 12 Fisheries Status in CT6 Countries, 2009

Country	Production[a] (t)	Maximum Sustainable Yield	Status
Indonesia	4,712,470	5.1 million t/year (Lymer et al. 2010)	Indonesia's fishery is still expanding but many parts of the resource are overexploited and in decline, particularly in Java Sea and Malacca Straits (Williams 2007).
		5.0–6.5 million t/year (Patlis 2007)	Most of the marine resources in the western part of Indonesian waters have been exploited intensively, while most resources in the eastern part still have room for development (FAO Country Profile: Indonesia).
Malaysia	1,369,692	1.6 million t/year (Lymer et al. 2010)	Many parts of the resources are overexploited with some fishing areas showing decline in fish biomass by as much as 90% of the level in the1970s (Williams 2007, Ahmad et al. 2003b).
Papua New Guinea	217,422 (catch by local fleets only) 327,471(including catch and bycatch of foreign-based fleets in 2007) (Gillett 2009)	0.4 million t/year for tuna (Mainardi 2010)	Tuna harvest is above MSY. It is recognized that there is a regional purse seine tuna vessel overcapacity (FAO Country Profile: Papua New Guinea). Current fish consumption is 13 kg/person/year, on the average, which is much lower than the estimated 34–37 kg/person/year to satisfy the recommended protein intake requirements (Bell et al. 2009).
Philippines	2,483,736	2.5 million t/year (Lymer et al. 2010)	Currently (based on 2010 and 2011), harvesting is beyond MSY considering IUU fishing in addition to the unaccounted subsistence fisheries contribution. Fish stocks in major fishing grounds have declined to less than 10% of the 1950s levels with evidence of continuous decline (Green et al. 2003, Lavides et al. 2010, Nañola et al. 2011). The oceanic large pelagics, such as marlin, swordfish, and sailfish, are not fully exploited at present (Barut et al. 2004).
Solomon Islands	27,918 (local fleets only) 98,023 (tuna catch of foreign-based fleets for 2007, including bycatch) (Gillett 2009)		Decrease in per capita consumption has been observed in many areas in Solomon Islands due to rising demand for fish, driven by increasing population (FAO Country Profile: Solomon Islands). National average fish consumption is 31 kg/person/year, which is lower than the estimated 34–37 kg/person/year to satisfy recommended protein intake requirements (Bell et al. 2009).
Timor-Leste	70 kg/km^2/year (average marine catch/unit area)	140 kg/km^2/year (average potential marine catch/unit area) (FAO Country Profile: Timor-Leste)	Fisheries are currently underexploited.

FAO = Food and Agriculture Organization of the United Nations; IUU = illegal, unreported, and unregulated; kg = kilogram; km^2 = square kilometer; MSY = maximum sustainable yield; t = ton.

[a] Classification includes crustaceans, marine fishes, and mollusks, based on FAO's International Standard Statistical Classification of Aquatic Animals and Plants (ISSCAAP) grouping.

Source: Modified from Cabral et al. (2013).

2. Reef Fisheries

The aggregate reef area of CT6 countries is approximately 86,000 km^2, excluding reefs in certain boundary areas; it is composed of 39,538 km^2 in Indonesia, 22,484 km^2 in the Philippines, 14,535 km^2 in PNG, 6,743 km^2 in Solomon Islands, 2,935 km^2 in Malaysia, and 146 km^2 in Timor-Leste (Burke et al. 2012). Indonesia has the most extensive mangrove cover at 35,000 km^2 and seagrass area of 30,000 km^2, while Timor-Leste has the smallest mangrove and seagrass areas estimated at 20 km^2.

Coral reefs are highly productive ecosystems. Unfished reefs in the Indian Ocean have been predicted to have an average fish biomass of some 120 t/km^2 (McClanahan et al. 2011). In Solomon Islands, 66 reef sites surveyed in 2004 had an average fish biomass of 212 t/km^2 if elasmobranchs are included; or 169 t/km^2, after excluding sharks and rays (Green et al. 2006).

Reef fisheries in the Philippines have been estimated to make a direct contribution of 15%–30% to the national municipal fisheries production (Aliño et al. 2004). The Philippines reef fisheries have experienced substantial decline with mean catch rates per vessel from more than 10 kg/day in the 1950s to less than 5 kg/day in the 1990s (Aliño et al. 2004). Malaysia's reef fishery resources fare better than those in Indonesia and the Philippines; but critical stocks, such as snappers and groupers, are still not managed effectively (CEA 2012).

Reef fisheries could sustainably yield 15–20 t/km^2/year (Maypa et al. 2002, Alcala and Russ 2002, McAllister 1988). This translates into a sustainable annual yield of 1.3–1.7 million t for CT6 countries. Based on the classification scheme used for identifying reef-associated groups in the FAO landing statistics, the CT6 reef-associated fish and invertebrate production reached 2.7 million t in 2007 and increased further to 2.9 million t in 2010. This is 60%–70% greater than the highest estimated sustainable annual yield.

3. Tuna Resources

Tuna stocks in the Western and Central Pacific Ocean, where the Coral Triangle is located, are regularly assessed by the Western and Central Pacific Fisheries Commission (WCPFC). About 59% of the world production of tuna comes from the Western and Central Pacific Ocean. Stock abundance of bigeye tuna (*Thunnus obesus*) and fishing mortality estimates indicate a possible overfished state for this species (ISSF 2012). Yellowfin tuna (*Thunnus albacares*) is not yet overfished, on average, for the entire Western and Central Pacific Ocean. However, they are estimated to be at least fully exploited in the Coral Triangle region and the rest of the western equatorial Pacific (ISSF 2012). Skipjack tuna (*Katsuwonus pelamis*) has benefited from higher-than-average recruitment levels in recent years. This species is only moderately exploited; overfishing is not yet occurring.

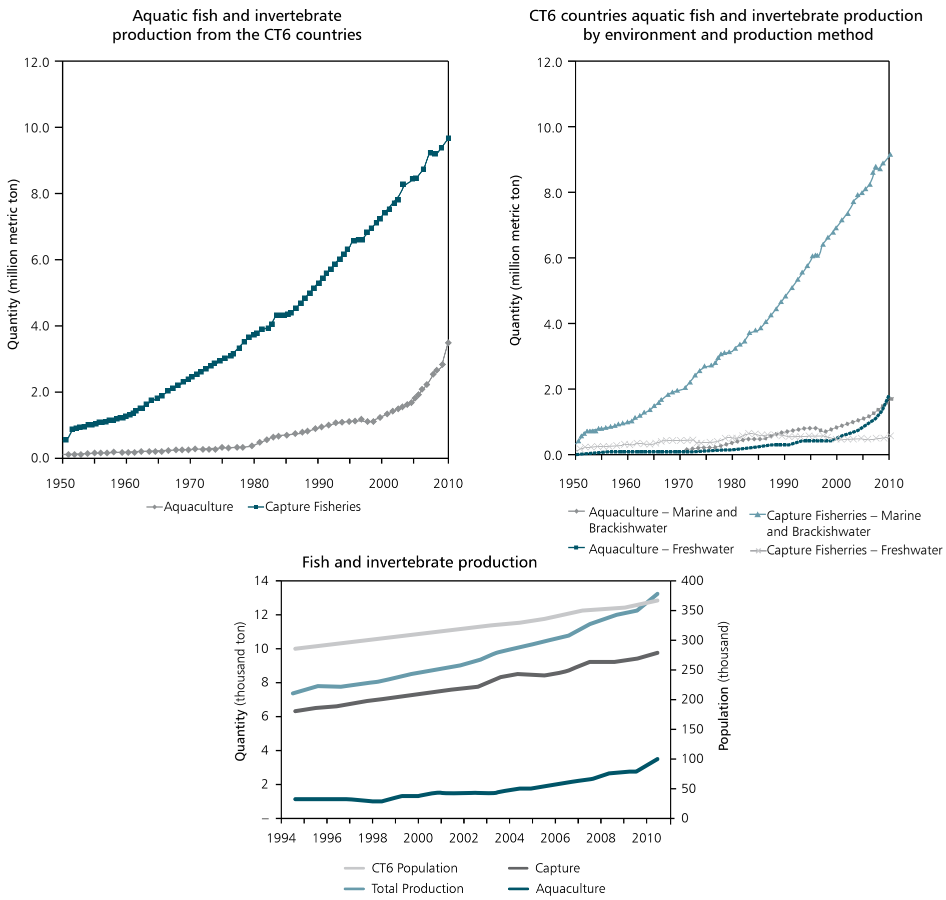
E. Projections of Fish Supply in CT6 Countries

Pertinent drivers of fisheries governance in the CT6 countries are population and development, and mariculture and/or aquaculture. Population growth rates have been stable over the last 5 years. The 2010 combined population of CT6 countries was about 373 million; and, considering a constant rate of population increase, it is projected to reach 430 million by 2020.

1. Regional Projections

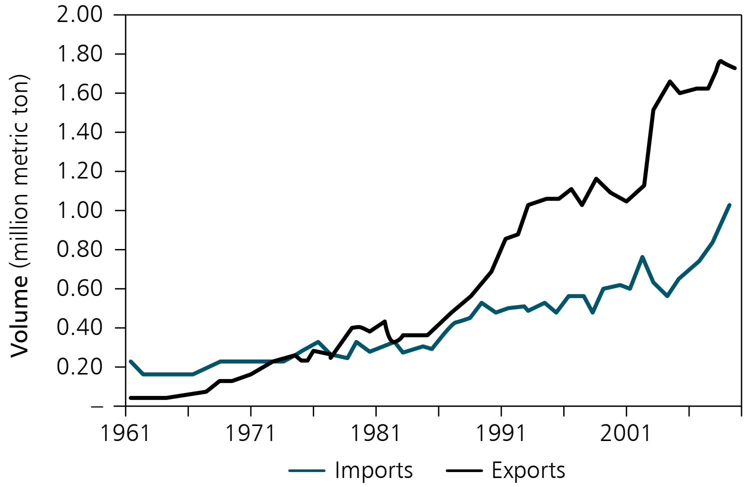
Fish production trends. Fish production trends from the FAO dataset on marine and inland capture and aquaculture fisheries are the bases for projecting production up to 2020 (Figure 14). Production is divided into two types (aquaculture and capture fisheries), in two environments (marine and/or brackishwater and freshwater). Capture fisheries for CT6 countries, which remain the dominant source of food fish, have been increasing at an almost linear rate since the 1950s. In contrast, aquaculture production has grown exponentially in 2001–2010, primarily due to the expansion of freshwater aquaculture, although marine and brackishwater aquaculture of fish and invertebrates has shown a linear trend.

Figure 14 Growth Trends of Aquatic Fish and Invertebrate Production in CT6 Countries (upper graphs) **Relative to Population Growth Trends** (lower graph)



Sources: Fish and invertebrate production data from FAO FishStatJ in FAO (2011b); population data from the World Bank Indicators. http://data.worldbank.org/indicator/SP.POP.TOTL (accessed 28 February 2013).

Figure 15 **Growth Trends in Export and Import of Fishery Commodities Aggregated for CT6 Countries, 1961–2010**



Source: Laurenti (2012).

Future production was projected by fitting linear regression functions to the production data at varying time slices and durations. Different estimates were generated based on growth rates averaged across different time periods. In general, production growth rates increased (except for inland capture fisheries) in more recent years than in previous decades. Hence, the projection, which considered only the trend in the last 3 years, gave the most optimistic estimate of production in 2020, as compared to projections using average growth rates in the last 2 decades. For inland fisheries, the production value for 2010 was not used because of the sudden increase in production from 2009, which was the reverse of the trend observed in the previous 10 years.

Fish trade projections. Fish imports by the CT6 countries help augment food fish supply, while exports reduce available food fish for the population of these countries. Overall, the CT6 countries have been net exporters of fisheries products since 1976 (Figure 15).

Projections of fishery commodity imports and exports were made using the linear regression trend from 2005–2009 for all CT6 countries, and for the individual countries based on the FAO Food Balance Sheet (Laurenti 2012). Projections show that by 2020, fish and invertebrate production in CT6 countries will increase to a moderate value of 17.1 million t, with a range of 15.5–19.4 million t, compared with the production of 13.2 million t in 2010. This translates into an annual per capita fish supply of 33.0–45.0 kg after accounting for the projected balance of trade.[16] Based on the 2010 CT6 per capita fish supply of 33.5 kg, the aggregate per capita fish supply is expected to increase for these countries as a whole, even following the slowest projected rate of growth. This projected growth depends more on the expansion of aquaculture

[16] This is calculated by dividing total fish production of the CT6 countries by their total population.

Table 13 **Projected Production of Fish and Invertebrates from Different Environments and Sources in 2020**

Parameter	Aquaculture (t) Marine and Brackishwater	Aquaculture (t) Freshwater	Capture Fisheries (t) Marine	Capture Fisheries (t) Inland	Overall	Per Capita Fish Supply (kg/year)
Base production, 2010	1,683,795	1,798,599	9,149,192	548,423	13,180,009	33.5
Projection Scenarios						
Slow growth scenario: Projected to 2020 using 2-year decade trend	1,798,187	1,949,556	11,285,455	454,757	15,487,954	33.1
Moderate growth scenario: Projected to 2020 using 1-decade trend	2,322,850	2,877,710	11,348,095	605,918	17,154,573	39.8
Fast growth scenario: Projected to 2020 using 5-year trend	2,906,713	3,715,396	11,110,649	684,149	18,416,908	42.8
Fastest growth scenario: Projected to 2020 using 3-year trend	3,158,903	4,169,959	11,291,416	773,496	19,393,774	45.0

kg = kilogram, t = ton.

Source: Authors' estimates.

production than from capture fisheries. Predicted production from capture fisheries does not vary significantly, based on the different historical trends used in the projections (Table 13).

Population growth rates for most of the CT6 countries decreased during 1994–2011.[17] However, for Indonesia, whose population accounted for 65% of the total CT6 population, its average growth rate increased during 2009–2011. The aggregate average growth rate of the CT6 countries during 1995–2011 was 1.6%. Future populations were projected to 2020 using linear regression.

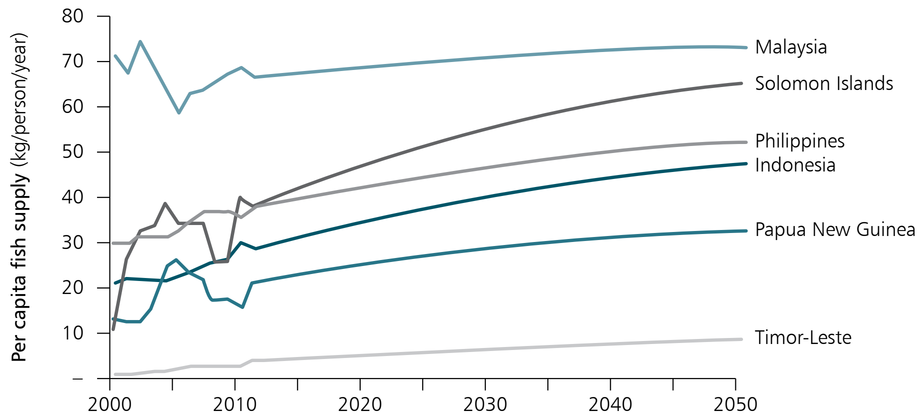
In the worst case scenario, it is characterized by marine capture fisheries no longer expanding, inland capture fisheries catches declining, and aquaculture production developing. Following the average trend in the past 2 decades, the total projected fish production for CT6 countries in 2020 is 13.4 million t, equivalent to fish supply of 31.2 kg/person/year. However, this trend is not consistent across all countries, as described in the next section.

2. National Projections

Given the importance of fisheries to their economy, poverty alleviation, and food security, the CT6 countries have set up targets for the further development of their respective fisheries sectors, with most of them targeting increased fish production.

[17] ADB. Statisics and Database. http://www.adb.org/statistics/

Figure 16 **Projected Per Capita Fish Supply in CT6 Countries, 2000–2050**



kg = kilogram.
Source: Author's estimates based on the growth rates of production, population, and trade during 2001–2010.

The per capita fish supply per country was projected using the 10-year (2001–2010) trend for total production of fish and invertebrates, population, exports, and imports. Results show that CT6 countries are all likely to increase their per capita fish supply (Figure 16), with Malaysia projected to have the highest per capita fish supply, followed by Solomon Islands, the Philippines, Indonesia, PNG, and Timor-Leste (in that order). The high per capita fish supply of Malaysia assumes a continuing increase in its fish imports at an average rate of 1.3% per year and growth of capture fisheries production at an average rate of 1.7% per year. Using the recent 3-year trend (2008–2010), the Philippines and PNG could experience reduced per capita fish supply owing to the slow rate of growth of capture fisheries in both countries in those 3 years (Table 14). Thus, these countries will have to improve their fisheries production performance from their record during 2008–2010 to be able to meet fisheries demand, and at least prevent their per capita supply from dropping.

The California Environmental Associates (2012) predicted an ill future for the fisheries of Southeast Asia, particularly for Indonesia and the Philippines. Their study, *Charting a Course to Sustainable Fisheries* identified the Southeast Asian countries as on the way to experiencing degraded fishery resources that will be worse than the degradation and decline experienced in developed countries. This scenario was seen to result from the lack of sufficient information, high incidence of poverty, and high dependency of many of the population on fishing as a livelihood. Aggravating factors include limitations in food supply, which constrain the capability of the CT-SEA countries to stall the decline, while helping affected households find other livelihood opportunities.

Indonesia. News articles revealed aggressive targets being set by Indonesia's Ministry of Marine Affairs and Fisheries (MMAF). Indonesia aims to increase the contribution of agriculture and fisheries to GDP by 2030, based on a report of McKinsey Global Institute (Oberman et al. 2012).[18] The same report predicted that a 7% per annum growth in real revenue from agriculture

[18] Listiyarini (2012). http://www.thejakartaglobe.com/business/indonesias-fishing-sector-targets-240-billion-y-2030/563899

Table 14 **Predicted Per Capita Supply of Fish and Invertebrates in CT6 Countries in 2020**

Country	Per Capita Fish Supply (kg/person/year)		
	Reference Value (2010)	Using Decade Trend Rate (2001–2010)	Using 3-Year Trend Rate (2007–2009)
Indonesia	29.7	34.9	45.3
Malaysia	68.8	68.7	83.2
Papua New Guinea	15.6	25.5	10.6
Philippines	35.8	42.4	32.9
Solomon Islands	40.2	47.5	101.8
Timor-Leste	3.0	5.3	5.3

Sources: Reference values from Laurenti (2012). Other numbers are from authors' estimates.

and fisheries can be achieved if key barriers are addressed by Indonesia. This would lead to an estimated increase in fisheries' real revenue to $40 billion by 2030, up from $10 billion in 2010; and $210 billion by 2030 for agriculture, up from $60 billion in 2010. Considering upstream and downstream sectors related to agriculture and fisheries, the total revenue from this sector could reach $450 billion in 2030 (Oberman et al. 2012).

For the fisheries sector, the MMAF initially set a high target of 22.4 million t of fish by 2015, almost double the reported fisheries production of 11.7 million t in 2010 (*Jakarta Post* 2011a), but the target was set for review and retargeting a month later (*Jakarta Post* 2011b). Aquaculture production was targeted to grow by 27% per year during 2010–2014 (Amri 2011). Indonesia also targeted to increase its fisheries product export value by at least $500 million in 2013 from $4 billion in 2012 (Priyambodo 2012), and planned to expand its export base for fishery products to the Middle East and Africa in addition to its existing three big markets—the United States, Japan, and the European Union (Baskoro 2012).

Malaysia. Its dependence on fish imports for its supply and the high proportion of trash fish in its catches make Malaysia vulnerable to fish supply shocks. However, its robust economy allows it to maintain a high per capita fish consumption. This is forecast to persist over the next 20–30 years. Development of inland and brackishwater aquaculture would further enhance Malaysia's fish food security.

Philippines. The Philippine Development Plan 2011–2016 presents concrete targets for the country's fisheries sector until 2016 (NEDA 2011). In terms of contribution to GDP, the country aims to increase its fisheries gross value added from P64,316 million to P83,756 million at 1985 constant prices. Production is targeted to increase by 28.3% from 5,163,000 t in 2010 to 6,624,000 t in 2016. Disaggregated according to production method and environment, commercial fishery production targets for 2016 was set at 16% (1,447,000 t) at 2010 values, and 19% (1,636,000 t) for municipal fishery production. The government's resolve to increase aquaculture production is evident in the plan, with the production target for aquaculture (3,541,000 t) 39% higher than the 2010 volume of 2,544,000 t.

Linear projections of production according to historical trends indicate that the targets set by the Government of the Philippines for 2016 can realistically be achieved. Using the historical trend from 2001–2010, predicted capture fisheries production for the country in 2016 will reach 3.14 million t, which is close to the target of 3.08 million t of combined commercial and municipal fisheries production. Projected aquaculture production by 2016 is also predicted to be slightly higher at 3.62 million t than the target of 3.54 million t. Similarly, per capita fish supply is projected to increase based on the 2001–2010 historical trends.

However, over the 3-year period (2008–2010), growth in total fisheries production in the Philippines slowed down to 3.1% compared to the average annual growth rate of 6.7% in 2001–2007. If this 3-year trend persists, per capita supply of fish is projected to decline from the 2010 estimate of 37.2 kg/person/year to 30.6 kg/person/year by 2030. Production will also fall short of the government's 2016 targets for capture fisheries by 309,000 t and aquaculture by 580,040 t. Other indicators of fisheries development identified in the Philippine Development Plan include increasing the net profit–cost ratio for the culture of milkfish (*Chanos chanos)* and tilapia (*Oreochromis niloticus*); and reducing postharvest losses from 25% in 2008 to 18% by 2016, which would also have a positive impact on fish supply.

Papua New Guinea. Using a comprehensive model of supply and demand for fish products, Bell et al. (2009) predicted that PNG and Solomon Islands will have problems meeting their future demand for fish. This is also reflected in the forecasts using the trend observed during 2008–2010. The PNG Strategic Development Plan 2010–2030 (DNPM 2010) targets the doubling of license fees from foreign fleets, from K60 million in 2008 to K120 million in 2030. The plan also focuses on tripling the volume and value of PNG-processed fish exports and increasing the quantity of catches of domestic tuna fleets from 1% of total tuna catch in 2007 to 20% by 2030. Aquaculture development is further seen to boost per capita fish supply and consumption.

Solomon Islands. The country is a net exporter of fish and does not import fish; its per capita consumption rate was estimated at 33.7 kg/person/year in 2007 (Laurenti 2012). Nearshore subsistence fishing meets 60% of the consumption needs of Solomon Islands, with fish accounting for almost 94% of animal protein consumed (Weeratunge et al. 2011). Projections based on FAO data for fisheries production show a highly optimistic future for fish supply in Solomon Islands. However, Bell et al. (2009) and Weeratunge et al. (2011) predicted otherwise. Like PNG, high costs of infrastructure and transport for distributing fish across the country to fish-scarce areas constrain the ability of the country to meet future fish demands. Maintaining and increasing the per capita consumption rate of fish in Solomon Islands will depend on (i) improving the country's processing facilities to extend the life of fishery products and allow the distribution to fish-scarce areas, (ii) stimulating domestic fisheries to access abundant resources accessed by foreign fleets, and (iii) enhancing aquaculture production although this option has limits given the available land area for setting up inland aquaculture.

Timor-Leste. Sector focus in Timor-Leste is on aquaculture expansion for food security. Aquaculture has the potential to increase food supply since relatively few Timorese are actively engaged in fishing. Projections on aquaculture production to 2030, using linear forecasting based on aquaculture production estimates during 2004–2010, yielded 7,806 t by 2030, as compared to 12,000 t targeted by the government in 2030 (MAF-NDFA 2012). Per capita fish consumption in Timor-Leste was estimated at 6.1 kg/year (MAF-NDFA 2012). This is higher than the calculation using data from FAO, which estimated per capita consumption of only 3.0 kg/year in 2010.

F. Summary and Conclusions

Fishing and fish farming are important contributors to the national economies and trade in CT6 countries. In addition, they provide livelihood to local communities, particularly those in the coastal areas, and are an important and relatively cheap source of protein for the countries' populations. In 2007, the total value of capture fisheries in CT6 countries was estimated at $11.7 billion, directly employing at least 4.6 million people and contributing 1.2%–6.8% of the national GDPs.

Unlike in many parts of the world, which are experiencing stable or declining fish production, capture fisheries production in most CT6 countries continues to rise. Aquaculture, both marine and/or brackishwater and freshwater, is expanding rapidly, although the major culture species have not changed much over the past decade.

Marine capture fisheries constitute the major source of fish supply for CT6 countries, with inland aquaculture augmenting supply to a limited extent. Marine and brackishwater aquaculture makes very minimal contributions to fish supply since seaweed comprise the bulk of the produce.

Projections of fish and invertebrate production highlight continuing growth in fish supply in CT6 countries, although the distribution of production varies widely across the countries. Marine and brackishwater aquaculture production will continue to increase rapidly, replacing marine capture fisheries production as the dominant source of fish produced by 2017. However, given the rate of freshwater aquaculture expansion observed in Indonesia, a big part of fish supply for the Coral Triangle region in the future will likely come from this source, next to marine capture fisheries.

The targets set by most CT6 countries are currently below the projected production volumes based on linear projections of historical trends. In the future, access to fish supply could become a more important issue—compared with volume sufficiency—for the Coral Triangle region, unless growth trends are reversed.

Aquaculture plays an important role in assuring fish supply in CT6 countries, but its future impacts depend on the rate of its expansion. The prices of fisheries commodities are affected by the rate of expansion of aquaculture—rapid growth would drive down prices of capture fisheries commodities, while slow growth will cause prices to rise by 19%–25% in 2020, and ultimately impact on access to fish supply (Delgado et al. 2003).

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III. Aquaculture Development Trends and Implications in the Coral Triangle

Annabelle C. Trinidad

A. Introduction

Traditionally, aquaculture has been treated askance by conservation projects similar to the Coral Triangle Initiative (CTI), mainly because of its likely adverse impacts on the environment. The Southeast Asian Fisheries Development Center Aquaculture Department (SEAFDEC-AQD) (2012) summarizes the negative externalities associated with the phenomenal growth of aquaculture, which include (i) modification, destruction, or complete loss of habitat; (ii) unregulated collection of wild brood stock and seeds; (iii) translocation or introduction of exotic species; (iv) loss of biodiversity; (v) introduction of antibiotics and chemicals into the environment; (vi) discharge of aquaculture wastewater, thus, coastal pollution; (vii) salinization of soil and water; and (viii) dependence on fishmeal and fish oil as aquaculture feed ingredients.

The negative externalities are some of the reasons that compel aquaculture to be mainstreamed into the CTI framework. They pose a threat or hinder the implementation of the ecosystem approach to fisheries management (EAFM) and marine protected area (MPA) management, and aggravate climate change impacts. Moreover, interactions between capture fisheries and aquaculture need to be analyzed from an economics perspective, to guide the actions of decision makers and inform the formulation of appropriate policies on resource use and management, among others (Willmann 2007).

This chapter revisits the CTI's regional plan of action (RPOA) and the national plans of action (NPOAs) of the CT6 countries to see how aquaculture is integrated into the broader fisheries management framework, and whether the countries view aquaculture as distinctly separate from fisheries management. It also discusses trends in aquaculture—past and future—with emphasis on government strategies, estimates future demand for trash fish based on historical information, and computes the financial requirements. It also includes case studies on fish kills from the Philippines, and emphasizes the direct and indirect costs (environmental and opportunity costs) associated with such occurrences. The information is expected to guide other CTI countries in their pursuit of aquaculture development.

B. Aquaculture in the Plans of Action

The RPOA is largely silent on aquaculture, reflecting the lack of appreciation of the interactions of aquaculture with capture fisheries; its impacts on the environment and coastal habitats; and policy focus, especially when viewed under the EAFM framework. In the RPOA, aquaculture is embedded under Goal 2 on EAFM goal, and its Target 2 on COASTFISH and Target 4 on sustainable live reef fish. Under COASTFISH, aquaculture is viewed as a livelihood option while the sustainability of live reef fish trade requires a full-cycle culture technology to stop the exploitation of juvenile fish. Two countries explicitly mentioned the activities related to aquaculture in the RPOA. In the Timor-Leste NPOA, Action 3 under Goal 2 involves the development of marine and brackishwater culture (e.g., seaweed, sea cucumber, milkfish, and groupers). The Philippines NPOA mentions full-cycle culture for live reef fish species.

Most CT6 countries recognize the potential for aquaculture as a strategy for food security and poverty reduction. However, the treatment of aquaculture in the NPOAs is sparse and it remains separate from the EAFM framework espoused in the CTI. Of the six countries, the Coral Triangle Southeast Asian (CT-SEA) countries consisting of Indonesia, Malaysia, and the Philippines—plus Papua New Guinea (PNG)—fully utilized the RPOA structure (Goals/Targets/Actions) as templates for their national plans. Solomon Islands and Timor-Leste developed their NPOAs based on their desired priorities. Some degree of overlap can be observed for Timor-Leste (Goal 2 on EAFM, Goal 3 on Priority Marine Conservation Areas, and Goal 4 on Climate Change). Solomon Islands capitalized on community-based resource management (CBRM) through cross-cutting themes, including CBRM implementation, policy and legislation, and data and information for coordination and decision making; and capacity building, education, and awareness raising.

Indonesia's NPOA follows the RPOA closely—its elaboration of aquaculture is confined to Goal 2, Target 2 on COASTFISH and Target 4 on live reef fish trade. Thus, there is recognition of the possible contribution of aquaculture to livelihood generation. To assure market acceptance, product standard requirements and monitoring of aquaculture activities are proposed (Table 15). The aquaculture strategy was developed by the Directorate General of Aquaculture, which is also under its Ministry of Marine Affairs and Fisheries (MMAF), but it is largely uninvolved with CTI concerns.

Malaysia has effectively woven aquaculture into Goal 2 by focusing on livelihoods, environment, technology, and knowledge transfer. It uses the Sulu–Sulawesi Marine Ecoregion (SSME) as a framework for addressing technology and livelihood issues of small fishers in Sabah, and seeks to establish a robust knowledge exchange with Indonesia and the Philippines. Supplementary to the CTI NPOA, the aquaculture strategy is articulated as part of the Third National Agricultural Policy (NAP 3), and is now implementing National Agri-Food Policy through 2020.

Aquaculture treatment in the **Philippines**' NPOA is limited to two points; but much more can be gleaned from the section on cross-cutting themes, which illustrates the broader framework in which aquaculture operates. These include research requirements (carrying capacity for aquaculture, exotic and/or invasive species, and cost–benefit analysis for full-cycle culture), policy development (fish farming or establishment of marine aquaculture parks), and capacity building (promoting environment-friendly aquaculture and equitable technology). The Comprehensive National Fisheries Industry Development Plan provides the framework for aquaculture development in the Philippines, but annual targets are prepared by the Bureau of Fisheries and Aquatic Resources (BFAR).

Table 15 **Aquaculture and Related Policies in the National Plans of Action**

Country	National Plan of Action Recognition of Aquaculture under Goal 2: Ecosystem Approach to Management of Fisheries			National Plans and Strategies Related to Aquaculture
Indonesia	**Target 2: Improved income, livelihoods, and food security**			Ministry of Marine Affairs and Fisheries Strategy
	Action	2	Develop community based capture fisheries and aquaculture enterprise in the border and remote areas	
	Action	3	Develop certification schemes for aquaculture products	
			Conduct monitoring and evaluation for aquaculture	
	Action	4	Develop fisheries product standard	
	Target 4: Achieved a more effective management and more sustainable trade in live reef fish and reef-based ornamentals			
	Action	2	Develop best practices for live reef fish trade, wild capture, or aquaculture	
Malaysia	**Target 2: Improved income, livelihoods, and food security**			Third National Agricultural Policy (NAP3)
	Action	1	Nominate selected coastal communities in Sabah to participate in the COASTFISH program	
	Action	2	As a Sulu Sulawesi Marine Ecoregion initiative, develop joint pilot projects with Indonesia and the Philippines to establish experimental farms for the culture of high value seaweed species, and share improved quality seed stocks for seaweed farms	National Agri-Food Policy 2011–2020
	Action	3	Rehabilitate abandoned shrimp farms to their natural state or for other sustainable aquaculture uses	
	Action	4	Address problems faced by seaweed farmers	
	Action	5	Develop economically feasible and ecologically suitable seaweed farming using best culturing techniques and seaweed strains in Sabah	
	Target 4: Achieved a more effective management and more sustainable trade in live reef fish and reef-based ornamentals			
	Action	2	Implement and adopt full-cycle aquaculture to alleviate pressure on wild stocks	
			Implement best management practice for aquaculture, with emphasis on the production of reef fish	
Papua New Guinea	**Target 2: Improved income, livelihoods, and food security**			Corporate plans of the National Fisheries Authority pursuant to the Fisheries Management Act of 1998
	Action	6	Build marine aquaculture research station in Kavieng	

continued on next page

Table 15 *continued*

Country	National Plan of Action Recognition of Aquaculture under Goal 2: Ecosystem Approach to Management of Fisheries	National Plans and Strategies Related to Aquaculture
Philippines	**Target 2: Improved income, livelihoods, and food security** Action 3 Conduct sustainability assessment of aquaculture production to attain twin objectives of food security and provision of livelihood opportunities	Comprehensive National Fisheries Industry Development Plan
	Action 4 Develop full-cycle culture projects for live reef fish species, especially high value species Rehabilitate mangrove forests and disseminate code of practice for aquaculture	Medium-Term Development Plan
Solomon Islands	**Based on key Ministry for Environment, Conservation and Meteorology/Ministry of Fisheries and Marine Resources policy overlaps** • Livelihood supplementation options: Test in three provinces, fish aggregation devices, freshwater culture, seaweed (Strategy for the Management of Inshore Fisheries and Marine Resources [SMIFMR] activities) • Key commercial species: Develop national management plans for sea cucumber, trochus, corals, dolphins, and live reef fish (SMIFMR activities)	Aquaculture Development Plan, 2009–2014
Timor-Leste	**Target 4: Achieved more effective management and more sustainable trade in live reef fish and reef-based ornamentals** • By third quarter of 2010, Timor-Leste will have started engaging with potential partners to define strategies to diversify household income in fishery-dependent areas (development of aquaculture, introduction of postharvest techniques, and other value adding alternatives). • By second quarter of 2011, Timor-Leste will have started the development of a white paper on aquaculture, linking aquaculture activities to poverty alleviation, alternative livelihoods and climate change adaptation." • By fourth quarter of 2014, Timor-Leste will have developed an aquaculture development plan that will become a part of Timor-Leste's coming National Development/Strategic Plan.	Timor-Leste Strategic Development Plan 2011–2030 National Aquaculture Delevopment Strategy 2012–2030

Sources: See Column 3.

PNG's NPOA recognizes the linkage between coastal fisheries and aquaculture as that intended by EAFM, yet none of its activities under Goal 2 reflects this thrust except to mention research in marine aquaculture by Kavieng College. PNG's aquaculture strategy is developed mainly by the National Fisheries Authority through its corporate plans. Several management plans have been developed pursuant to the Fisheries Management Act of 1998, including the Barramundi Management Plan and the Bêche-de-Mer Management Plan.

The **Solomon Islands** NPOA does not propose specific activities related to aquaculture, but reiterates the plans of the Ministry of Fisheries and Marine Resources (MFMR). The National Aquaculture Plan (2009–2014) has been prepared and priority commodities identified based on two prioritization exercises. The prioritized commodities are seaweed, sea cucumbers, tilapia, and marine ornamentals.

Timor-Leste's elaboration of aquaculture in its NPOA recognizes aquaculture's role in generating income and alleviating poverty. It includes, as a CTI activity, the preparation of an aquaculture strategy, which has been accomplished; it promotes aquaculture as a means to combat prevalent malnutrition.

C. Aquaculture Development in the Coral Triangle

Total fishery production of CT6 countries reached 19.1 million tons (t) in 2010, of which 9.7 million t were contributed by the aquaculture sector. Marine aquaculture comprised 5.7 million t, 95% of which was from Indonesia and the Philippines. The increase in freshwater fisheries production came only from the exponential growth of aquaculture. Since 2005, the growth rate of freshwater aquaculture has averaged 16% per year.

In CT-SEA countries, aquaculture has had a long history; and has been contributing significantly to domestic food requirements, export revenues, and employment. In contrast, the CT-Pacific countries of PNG and Solomon Islands have experienced a floundering aquaculture sector, but there is a resurgence of interest mainly because of their increasing populations and food requirements. Timor-Leste's approach is articulated in its Aquaculture Development Plan, which aims to combat widespread malnutrition by raising annual per capita consumption levels from 6.1 kilograms (kg) to 15 kg to attain global fish consumption standards.

Several factors support the development of aquaculture in the Pacific, including its geography, which boasts of inshore marine resources and habitats; diversity of coral reef species that can be tapped for the seafood market, aquariums, and pharmaceutical inputs; and pristine coral reef ecosystems used for restocking and stock enhancement. However, the challenges are many, including high transport costs; and lack of domestic markets, freshwater resources, physical infrastructure support, and technology and know-how.

Indonesia. This country has vast resources that offer a huge potential for aquaculture development. The extent of areas with potential for aquaculture is estimated at 15.6 million hectares (ha), composed of 2.2 million ha of freshwater bodies, 1.2 million ha of brackishwater areas, and 12.1 million ha of marine areas. To date, 10% of freshwater, 40% of brackishwater, and 0.01% of marine areas potentially suitable for aquaculture are in use (Nurdjana 2006).

Aquaculture in Indonesia gained importance in the 1970s (FAO 2008–2013) because of the development of seed and feed technology, although its history could be traced to the mid-19th century when carp was stocked in backyard ponds. During the late 1970s, a big boost to shrimp culture occurred when the eyestalk ablation technique was discovered; now, shrimps comprise more than 80% of production from brackishwater systems (Nurdjana 2006). Almost 50% of fisheries production in Indonesia is contributed by aquaculture, and it is the fourth top producer in the world (Indradjaja 2010). Given the resource potential of the country and the mostly unutilized capacity in all operating environments, continued growth in the sector is expected. Sari (2010) reported that aquaculture in marine areas is now growing faster than in brackishwaters, owing to the huge demand for seaweed and the Asian seabass.

Malaysia. This country has had a long history of aquaculture, starting in the 1920s with the culture of carps in ex-mining pools. This was followed by shrimps in the 1930s, blood cockles in the 1940s, and semi-intensive farming of shrimps in Johore in the 1970s. At about the same time, floating cage culture of groupers started. By the 1980s, Malaysia's aquaculture had become commercialized as more intensive farming systems and supplemental feeding were introduced. Brackishwater species now account for more than 70% of total aquaculture production in terms of value and quantity. Of these, blood cockles record the highest production, followed by marine shrimp and freshwater species, such as tilapia, carp, and catfish; and marine fish. Cockles account for almost 50% of the total brackishwater aquaculture production and about 37% of annual aquaculture production.

Most freshwater commodities are marketed domestically while tiger prawns (shrimps), groupers, and seabass are exported to Hong Kong, China; Singapore; and Taipei,China. The NAP3 targeted a 200% production increase in aquaculture by 2010, but failed to achieve this because of difficulties in land acquisition, rising production costs, and lack of skilled workers. As a manifestation of its serious commitment, the government declared the Aquaculture Investment Zone and allocated 40,000 ha for investment. The years leading up to 2020, by which time the National Agri-Food Policy would have been completed, are crucial, mainly because Malaysia aims to join the ranks of high-income economies by then. This would have huge implications on the consumer base, which would be more discerning and more demanding in their food choices. Consumers would expect a wide variety of choices; choose food for its nutritional value; and be more sophisticated and/or aware, requiring high product standards and environmental safeguards.

Philippines. From 2001 to 2011, the aquaculture sector in the Philippines produced an average of 2 million t, worth P60 billion ($1.5 billion) annually. Food fish (excluding seaweed) comprised 31% of the total volume produced and 89% of the value. Aquaculture contributes significantly to the country's food security, employment, and foreign exchange earnings. Approximately 18% of fish food supply comes from aquaculture, notably milkfish and tilapia (FAO 2008–2013). Aquaculture is growing much faster than capture fisheries. However, the global position of the Philippines in aquaculture production has fallen steadily from 4th place in 1985 to 12th place in recent years (FAO, 2008–2013).

Lopez (2006) enumerated some of the issues the Philippines has to address to improve the performance of the aquaculture sector: stringent hazard analysis and critical control point protocols that fish farmers find hard to comply with because of cost-ineffectiveness and changing standards. For example, the traceability requirement is not just limited to farmed produce but also to inputs like seeds and feeds. Maintaining good environmental management is essential to prevent self-pollution and massive fish kills. Among the thrusts required to sustain the role of aquaculture in providing food, income, and export revenues is the further development of hatchery technology for high-value species to diminish dependencies on wildstock, i.e., live reef fish.

The government will sustain its investments in marine aquaculture parks and "highways" to attract private sector investment and improve the accessibility of produce to consumers.

Now, there are 11 well-established and operational marine aquaculture parks across the country, catering to local, national, and foreign investors. These are mostly engaged in farming of milkfish and other high-value species, such as grouper, rabbitfish, and jack.

Papua New Guinea. The PNG State of the Coral Triangle report acknowledges that aquaculture in the country is not well-developed (PNG CTI NCC 2012) although it started 40 years ago, with several aquaculture stations along the coast and highlands to encourage subsistence culture, mainly of *Cyprinus carpio* (Adams et al.2001). Coates (1989) noted that traditional aquaculture in PNG is virtually nonexistent. Fish introduction of about 29 species, not all of which were destined for aquaculture, was one of the approaches taken. However, due to limited fish biodiversity (Edwards 2009), nearly all these introductions proved unsuccessful, except for tilapia, which escaped into the Sepik River and now accounts for roughly half of the yield of capture fishery.

PNG aquaculture development was stagnant until recently, with low-level commercial operations for trout, barramundi, pearl, and shrimp.[19] The Australian Centre for International Agricultural Research (ACIAR) reported that in 2007, 5,418 known tilapia farms operated in PNG and 10,000–15,000 farms with fishponds. With more than 80% of PNG's population living in the highlands (Coates 1989), it is logical to assume that freshwater aquaculture will thrive better than marine aquaculture. Highland farmers are responsive to the promotion of aquaculture as their needs for food and income-generating activities are substantial. Edwards (2009) recommended Markham Valley as having potential for large-scale commercial aquaculture because it has a flat topography, more available water, and land is more readily accessible. It is close to the major urban market of Lae that has a reported significant and largely unmet demand for tilapia indicated by a high retail price of about $5/kg. The initiatives of the National Agicultural Research Institute to use local materials as feed sources for pond fish; and support to mini-hatcheries for fingerling production, pond development, and integrated aquaculture, may be some of the ways to improve the sector (Laraki and Tapat 2011).

Solomon Islands. The aquaculture industry has had limited contribution to the livelihoods of the rural sector in Solomon Islands, despite the wide range of species cultured, such as giant clams, shrimps, freshwater prawns, pearl oysters, seaweed, sea cucumbers, hard and soft corals, milkfish, sponges, and the capture and/or culture of postlarval animals (Lindsay 2007, SIMFMR 2009). Coral culture (hard and soft) has provided small-scale, sustained economic benefits through the successful development of community-based farms that service private sector aquarium companies (Lindsay 2007). But technical and economic constraints still plague the widespread adaptation of coral farming (Lal and Kinch 2005). Private sector efforts can be credited for *Macrobrachium*, marine shrimp, and seaweed research; and the WorldFish Center for giant clam, pearl oyster, and coral farming. However, most aquaculture and rural development activities ceased during the ethnic conflict from 1999 with effects felt up to 2003.

Aquaculture of inshore resources in Solomon Islands offers opportunities to create new livelihoods and export commodities, while freshwater aquaculture can supply fish for food in areas where inshore fisheries are limited and tuna is difficult to access (SIMFMR 2009). Thus,

[19] National Fisheries Authority. http://www.fisheries.gov.pg

the Aquaculture Development Plan identified, based on impacts and feasibility, four priority groups—seaweed, tilapia, sea cucumber, and marine ornamentals. Proposed actions related to corals include (i) developing policies to replace the sale of wild corals with farmed corals for easily cultured species; (ii) encouraging farming of fast-growing coral species; and (iii) improving coral farming skills of provincial officers, particularly in provinces near Honiara (Sandfly/Nggela).[20]

Timor-Leste. Brackishwater aquaculture for milkfish and shrimps started in 1987 in Nino Konis Santana National Park, but many of the coastal ponds are in dire need of repair (Andrew et al. 2011). Seaweed farming (*Eucheuma* sp. and *Kappaphycus* sp.) began in 1989, and seaweed comprised the main marine aquaculture crop in Timor-Leste. One 3-hectare farm located outside Dili produced around 2 t/year in 2008 and 2009, equivalent to $1,300/year. Seaweed is exported, with reported markets in Indonesia, the Philippines, and Viet Nam; and there is some very limited local consumption of some species (Andrew et al. 2011). Freshwater aquaculture, particularly of common carp, was promoted in Aileu, Ermera, Manufahi, and Viqueque districts, where freshwater fish hatcheries were established.

Timor-Leste prepared the Aquaculture Development Plan as an activity under Goal 2 of the NPOA because the country's Strategic Development Plan through 2030 gives importance to fisheries and aquaculture. The targets of Timor-Leste are to increase per capita consumption of fish from the current level of 6.1 kg to 15.0 kg in the medium term, and contribute up to 40% of domestic fish supplies in the long term (MAF 2012). Priority districts and aquaculture types are the following:

(i) *Freshwater aquaculture in* Baucau, Bobonaro, Ermera, and suitable agroecological areas in other districts. Bobonaro and Ermera have the highest proportion of population suffering from malnutrition and, therefore, offer greater potential for aquaculture to improve food and nutrition security. Tilapia and carp are the target species.
(ii) *Brackishwater aquaculture in* Covalima, Dili, Liquica, Manatuto, and Oecussi districts. Milkfish, seaweed, and, possibly, shrimp are the target species.
(iii) *Mariculture in* Dili, Liquica, and Manatuto districts. Sea cucumber and, possibly, mudcrab are the target species.

D. Interactions between Capture Fisheries and Aquaculture

Interactions between capture fisheries and aquaculture are varied. While this section focuses on aquaculture's demand for trash fish for reduction purposes, other issues highlight the need for more integrated management of aquaculture and capture fisheries: (i) alien species introduction mainly for aquaculture purposes but with risks of escape (Coates 1989), (ii) disease, (iii) damage to habitats and wild biodiversity, (iv) pollution, (v) biotechnology concerns (transgenic fish), and (vi) capture-based aquaculture (collection of juvenile for grow-out, as in the case for the live reef fish industry). Aquaculture and capture fisheries share the same environment, are affected by the same externalities posed by climate change and

[20] In Chapters V and VI, the significance of ecosystem services derived from coral reefs is emphasized, including their contribution to subsistence fisheries, while highlighting the continued high demand for coral exports (curio and aquariums) and the possibility of rethinking coral farming as an alternative to wild harvest.

development activities, and need the same resources (human and capital). Unfortunately, the approach to policy development and institutional arrangements neither reflects this nor is it apparent in the CTI.

While recognizing the many issues relating to capture fisheries and/or aquaculture interaction, this study focused on the demand for trash fish in view of its importance within the EAFM framework. Aquaculture, while seen as an engine to address food security and reduce poverty, also poses a threat because of the increasing demand for trash fish, which is consumed as food fish in less developed economies. In addressing the overall food security outcome of the CTI, the EAFM strategy must consider synergies and trade-offs between wild capture fisheries and aquaculture for food security (Foale et al. 2012). The previous discussion about development trends shows the increasing focus of the CT-SEA countries on marine aquaculture and the preference for high-value species.

Ye and Beddington (1996) suggested aquaculture as an option to reduce pressure on wild stocks; but Hannesson (2003) countered that long-term supply provided by capture fisheries is likewise imperiled, especially in open access fisheries. To sustain the demand for food fish spurred by growing populations and improved incomes in both the CT6 countries and those that have robust trading relationships with the CT6, aquaculture is often regarded in the light of the Ye and Beddington proposal. Yet, the demand for seeds and feeds from capture fisheries has not been factored in the equation. The threat to long-term sustainability of both aquaculture and capture fisheries is also a concern. Carnivorous fishes, such as groupers, snappers, and barramundi, directly consume trash fish, which are also converted into components of fishmeal for milkfish and shrimps.

Trash fish remains the method of choice for many farmers, especially those farming low-volume species, such as snappers (*Lutjanidae* spp.), groupers (*Epinephelus* spp. and other serranids), and many other marine fishes for which aquafeed manufacturers have difficulty developing economically competitive pelleted feeds as an alternative to trash fish (Williams and Rimmer 2007). Stobutzki et al. (2007) estimated that in 2003, 96,000 t of trash fish were required in Indonesia for use directly as aquaculture feed, 45,000 t in Malaysia, and 16,000 t in the Philippines; and close to 500,000 t required as pellet components. The likely demand of the individual Coral Triangle countries for trash fish to sustain their aquaculture targets is assessed below, based mainly on their agriculture or aquaculture strategies and news reports.

Trash fish requirements for Indonesia, Malaysia, and the Philippines were all adjusted upward from the initial estimates of Stobutzki et al. (2007) based on more updated production targets. The three CT-Pacific countries are expected to have negligible demand for trash fish, based on their priority species and/or farming systems (Table 16).

Indonesia. Aquaculture production in Indonesia reached 7.0 million t in 2011, and 9.4 million t was targeted for 2012. The 2011 production consisted of seaweed (4.3 million t), milkfish (582,242 t), tilapia (481,440 t), shrimp (414,014 t), catfish (340,674 t), carp (316,082 t), *Pangasius* (144,538 t), gourami (59,401 t), grouper (12,561 t), and other species. The average fishmeal requirement is estimated at 150,000 t (Table 16), and the catch of Bali sardinella *(lemuru)* of 162,000 t is considered an indication of the trash fish requirements of Indonesia's aquaculture.

Table 16 Value of Trash Fish Required for Aquaculture in CT6 Countries

Country	Estimated Demand for Trash Fish	Main Species Targeted for Aquaculture Requiring Direct Feeding of Trash Fish	Main Species Targeted as Trash Fish or for Use as Fishmeal	Value of Trash Fish
Indonesia[a]	Medium, historical demand is 150,000 t of fishmeal a year	Grouper Gourami	Pelagic fishes, like Bali sardinella (*lemuru*), are the best base for fishmeal because of its high protein content. Other species used for fishmeal in Indonesia are *ikan pepetek* or ponyfish (Leiognathidae); *ikan layang* or scad (Decapterus, *spp.*); sardine (spotted sardinella, rainbow sardine); and some disposals from tuna, mackerel, and sardine canneries.	$75 million based on price of $0.50/kg
Malaysia[b]	High, about 800,000 t based on a target production of 165,000 t of marine fish and average feed conversion ratio of 5:1 for mariculture species	Seabass Snapper (lutjanids), grouper (serranids), mud crab	Clupeids or sardines (*Clupea* spp.) Mackerels (*Caranx* spp.) Anchovies (*Engraulis* spp.) Mullet (*Mugil* spp.) Catfish (*Tachysurus* spp.) Jewfish (*Pseudosciaena* spp.) Lizardfish (*Saurida spp.*) Squids Mantis shrimp	$640 million based on price of $0.80/kg
Papua New Guinea	Not estimated	Historically, rainbow trout and tilapia in highland farms; mariculture emphasis is on seaweed, giant clam, crocodile, milkfish, mullet, mussel, oyster, and prawn		Not estimated
Philippines[c]	Medium, about 128,000 t based on historical usage	Grouper Cavalla Snapper	Round scads Fusiliers	$90 million based on price of $0.70/kg
Solomon Islands[d]	Not applicable	None. Priority aquaculture commodities are seaweed (K. alvarezii); tilapia; sea cucumber; and marine ornamentals, including corals and giant clams.	Not applicable	Not applicable
Timor-Leste[e]	Low	None. Focus is on freshwater culture of carp and tilapia.	Not applicable	Not applicable

kg = kilogram, t = ton.
Sources:

[a] Information for Indonesia is based on the position paper Sustainable Sources for Fishmeal in Indonesia to Support Good Aquaculture Practices, 8 May 2012. http.//cmsdevelopment.sustainablefish.org.s3.amazonaws.com/2012/07/12/Sustainable%20Fishmeal%20in%20Indonesia-Summary-8%20May%202012-9f55a976.pdf; and price is based on Rp4,000/kg ($0.50/kg based on $1= Rp9,600) and used the presentation of Gede Sumiarsa and Lukas Manomaitis on Fish Aquaculture Production with regard to Feed and Feeding Management in Bali, Indonesia.

[b] Production targets are based on pronouncements of the Fisheries Department (New Straits Times 2012) and the percentage composition of major species group that is based on the Third National Agricultural Policy (Othman n.d.). Species used as trash fish are based on FAO (1985) and Musa and Nuruddin (2007). Trash fish price for Malaysia is based on RM0.26/kg during high season (Stobutzki et al.) and RM5.0/kilogram during low season (Chun 2007) or average of $0.80/kg based on an exchange rate of RM3 = $1.

[c] Target for the Philippines is based on FAO (2004), adjusted per contribution of marine cage culture. Preferred species for culture and trash fish requirements are based on Lopez (2006), while price of trash fish is based on the price of round scads and fusiliers of $0.73/kg to $1.7/kg (Bureau of Agricultural Statistics).

[d] Based on the National Aquaculture Plan.

[e] Based on Timor-Leste's National Aquaculture Strategy.

Malaysia. The NAP3, which ended in 2010, showed a shifting focus to marine finfish from shrimp farming, which had traditionally dominated aquaculture production because of higher income and export potential. Initially regarded as a small and/or backyard industry, marine finfish farming is now a commercial enterprise that produces high-value marine species such as groupers, seabasses, and snappers. The *New Straits Times* reported in 2012 that Fisheries Department Director-General Datuk Ahamad Sabki Mahmood announced a production target of 800,000 t of fish in 5 years, higher than the current production of 380,000 t, in cognizance of the higher demand brought about by the increasing population (*New Strait Times* 2012). Using the same proportion of marine fish from NAP3 (i.e., 20% of total targeted production), 160,000 t of fish is estimated to be targeted for aquaculture production, which translates to a requirement of 800,000 t of trash fish, based on a 5:1 food conversion ratio (FAO 1985).

Philippines. The estimate for the Philippines is based on historical requirements for trash fish (i.e., 150,000 t), of which an estimated 80% is used for marine cage culture (FAO 2004).

Papua New Guinea. Freshwater aquaculture will continue to drive aquaculture in PNG, mainly because most of the population live in the highlands (>1,400 meters [m] above sea level) (Smith and Mufuape 2007). Initiatives in aquaculture include cultivation of silverlip pearl oyster (*Pinctada maxima*), prawn culture in Rabaul, and setting up a seabass hatchery in Daru, Western Province (FAO 2010). A projected commercial operation of seabass farms will eventually require feeds, potentially including trash fish, but the requirements have not yet been estimated. The corporate plan of the National Fisheries Authority for 2008–2012 focuses on aquaculture development rather than maintenance of existing aquaculture systems.

Timor-Leste. Timor-Leste's national aquaculture strategy aims to increase fish supply from aquaculture to a target of 12,000 t by 2030, with 9,000 t coming from freshwater aquaculture, mainly of carp and tilapia, to reach the annual per capita consumption target of about 15 kg. Aside from improving nutrition, at least 40,000 households are envisioned to derive income benefits from this form of aquaculture. For marine aquaculture, the target species are sea cucumbers, seaweed, and crabs. Thus, the demand for trash fish for aquaculture is low in Timor-Leste. The same is true for Solomon Islands, based on the National Aquaculture Strategy (2009–2014) and the priority commodities indicated in Table 16.

The issue on trash fish consumption goes beyond the huge volume requirement and cost. Estimates from the present study showed that at least 1 million t of trash fish are required to support the culture of high-value species in CT6 countries, based on current plans and targets. Incorporating trash fish for reduction purposes (fish meal, pellets, and fish oil) shows conservative estimates at 20% of total aquaculture production for the CT-SEA countries. The estimate is not surprising given that in 2006, the global consumption of the aquaculture sector was equivalent to 23.8 million t of small pelagic forage fish in the form of feed inputs, including 3.7 million t of fishmeal and 0.8 million t of fish oil in aquafeeds (equivalent to 16.6 million t of small pelagic forage fish), and 7.2 million t of low-value and/or trash fish as a direct feed or within farm-made aquafeeds (Tacon and Metian 2009).

In less developed economies, trash fish is defined as fish with low commercial value. It does not mean that it is unpalatable and useless, especially if further processing transforms it into usable food or condiments. What may be regarded as trash fish to some is food fish to others, leading to the conclusion that food fish is taken away from the poor sector of the population to serve as feeds for fish to the wealthier sector. The increasing demand for trash fish as feeds for carnivorous species have increased prices, which in turn, have resulted to decreased availability at local rural markets (Troell 2006). Since trash fish includes discards, bycatch, and even juvenile food fish, increasing prices may lead to more wanton fishing practices instead of strict compliance with responsible fishing guidelines because a market exists for the catch (Stobutzki et al. 2007).

The source of trash fish in Malaysia and the Philippines is trawl fishing. Most of the dominant families comprising trash fish are being exploited beyond maximum sustainable yield, especially fish that have other commercial value (Stobutzki et al. 2007). The same report als counted 12 out of 50 fish families as being "true trash," while 93% consist of families with other commercial value. Willmann (2007) held a contrary opinion and observed that there was yet no evidence that expanding aquaculture had significantly contributed to increased fishing pressure on reduction fish species. The primary reason for overexploitation is the absence of effective fisheries management and increase in the demand and price of food fish.

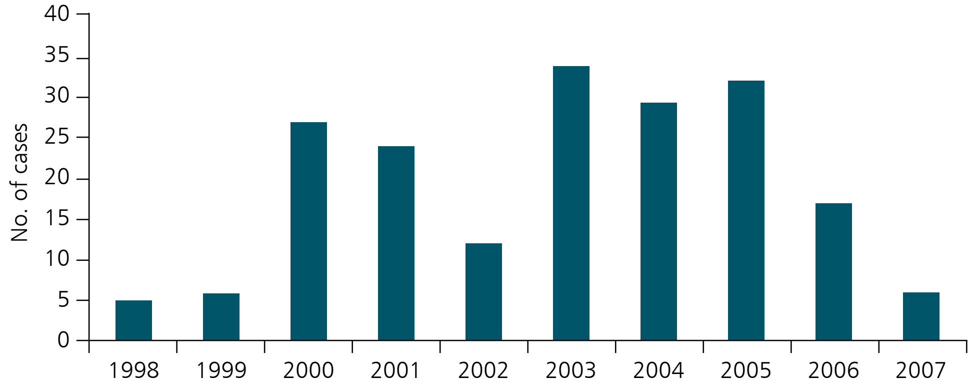
The resources required to support marine aquaculture, not to mention the indirect use of trash fish as components of fishmeal, are enormous. While aquaculture contributes to food and incomes, its development thrust must not be pursued in a vacuum, especially when such relationships with capture fisheries exist. For example, it is important to determine whether aquaculture and capture fisheries are supplying the "same commodity" as this would have an impact on total supply and prices based on substitution effects. One of the other "hidden costs" is associated with the catch of juvenile commercial species, which frequently occurs as trash. Lastly, the interaction between trash fish demand from the aquaculture sector and capture fisheries illustrates the need for better fisheries management, using closed areas and regulating inputs and outputs, among other interventions. By ignoring the threats posed by excessive use of fish protein as feeds, the objectives of the two sectors may be unattainable in the long run.

E. Hidden Costs of Fish Kills: A Case Study from the Philippines

"It is convenient to blame nature for disasters that ultimately are caused (or at the very least exacerbated) by human actions or inaction, and fish kills are no exception" (Jacinto 2011).

A fish kill is any unusual and noticeable increase of mortality because of infectious or noninfectious causes in wild or captive fish or shellfish populations. Oxygen depletion, pollutant toxins, natural toxins, and diseases are four common causes of fish kills that can be traced directly or indirectly to aquaculture activities (BFAR-PHILMINAQ 2007). Based on records from the Bureau of Fisheries and Aquatic Resources (BFAR) Fish Health Monitoring Service, 192 fish kills occurred during 1998–2007 (Figure 17). Marine fish cages and freshwater cages and pens are the usual aquaculture systems affected by fish kills. The fish most involved are tilapia and milkfish, although other species have also been affected—eels, gobies, clams, and mullets. Of the 192 cases documented by BFAR, at least 55 can be traced to bad aquaculture practices, such as overfeeding, overstocking, and use of chemicals leading to dissolved oxygen depletion. For this data set, the listing of "overturn" was also attributed to bad aquaculture practice.

Figure 17 **Fish Kill Occurrences in the Philippines, 1998–2007**



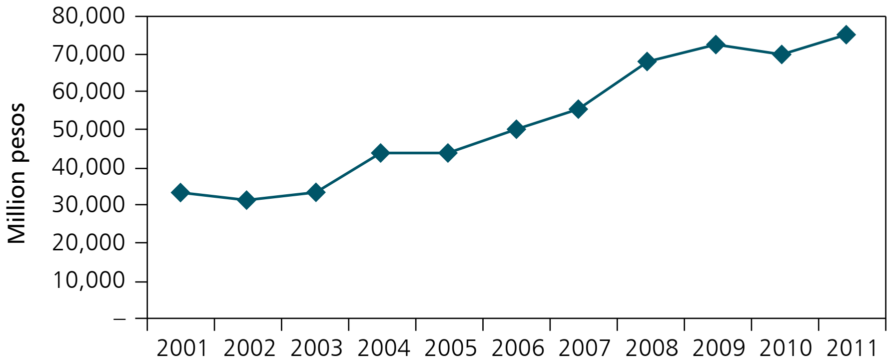
Source: Bureau of Fisheries and Aquatic Resources Fish Health Monitoring Service.

The rest of the data set lists the following as proximate causes of fish kills: (i) diseases, such as the white spot virus plaguing shrimp farms, and parasitic and fungal infections; (ii) mishandling of fries and/or juveniles prior to stocking; (iii) chemical pollutants from nearby industrial establishments; (iv) harmful algal blooms; and (v) presence of poisons such as cyanide and pesticide contamination. Inquiries with BFAR revealed that its Central Office has stopped consolidating data on fish kills and has assigned this function to the regional offices. Patchy news reports were gathered to update the fish kill incidents. In 2010, fish kills were reported in two freshwater environments—Magat Dam and Lake Buhi (June and November). In 2011, the largest fish kills occurred in the coastal municipalities of Anda and Bolinao in Pangasinan Province, where cages of milkfish were affected; and in Taal Lake, a freshwater lake located south of Manila, affecting freshwater cages and pens farming tilapia.

The largest and most publicized fish kills can be traced to irresponsible aquaculture. In Bolinao, Pangasinan, two major fish kills occurred in 2002 and 2007, and a minor one in 2011. All incidents can be traced to overstocking, overfeeding, and overcapacity of cages in the Caquiputan Channel, where water flushing was observed to be slow. In 2002, the losses were estimated at P200 million–P500 million; while in 2007, the losses were placed at P70 million–P140 million. The impacts of the fish kill cascaded even to the fishing industry beyond the locality as prices of fish plummeted; and consumers stayed away from eating fish, in general, not just milkfish from Pangasinan (Jacinto 2011).

In 2011, the fish kills in Taal Lake reached disastrous proportions. About 2,000 t of fish, mostly tilapia, valued at about P190 million, were killed from May to June 2011. For days, the fish kill was prominent in the media. It was an event that merited the attention of the local governments abutting Taal Lake, the Department of Agriculture, the National Disaster and Risk Reduction Management Council, and the Department of Social Welfare and Development (DSWD). Telltale signs started in 1998, when the fish kills started to occur, and peaked in 2000, with nine incidences in that year alone.

Figure 18 **Aquaculture Production in the Philippines** (excluding seaweed), **2001–2011**



Sources: Bureau of Agricultural Statistics. *Fisheries Statistics of the Philippines*, various issues.

When viewed from a national perspective, the economic losses resulting from fish kills are insignificant. After deducting the value of seaweed production, the annual revenues from aquaculture were worth P30 billion–P70 billion, thus, rendering even the maximum loss of P500 million relatively insignificant (Figure 18).

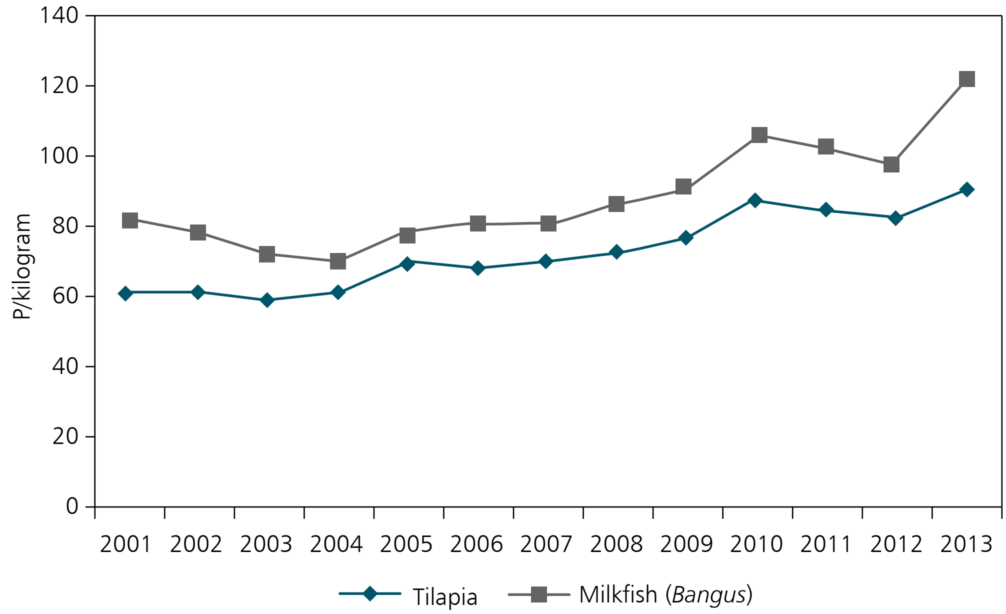
However, the 2011 fish kill in Taal Lake provides a good example of various "hidden" costs. Aside from the direct costs associated with the dead fish, the other economic costs are (i) cash released by DSWD for work amounting to almost P9 million; (ii) expenses incurred by the national and local agencies for hauling and disposing of dead fish, rehabilitation, and credit; (iii) loss of economic opportunities to suppliers of inputs to aquafarms and forward market linkages; (iv) blight on Taal Lake's tourism image; (v) opportunity cost of capital invested in fish farms, especially if on credit; and (vi) market avoidance of fish alleged to be sourced in the environs. Estimates of these "hidden" costs bring the total loss to more than P250 million, or at least 40% higher than the value of direct costs.

The loss of 2,100 t from the fish kills in Taal Lake represents a little less than 10% of the annual production of tilapia. However, this same quantity of fish can feed almost 60,000 persons for 1 year based on a per capita consumption of 38 kg/year. A survey of tilapia farming shows that fish is consumed 5–6 times a week in households along lakeshore municipalities, and tilapia is eaten almost daily by 30% of household respondents and at least 3–4 times a week by 33% of households (ADB 2004). The fish kills in Pangasinan were said to have directly affected the supply of milkfish in Metro Manila markets because this region provides at least 50% of supply.

The desire for more profits is usually seen as the main economic driver behind the perennial overstocking of fish. With an increasing population, prices of milkfish and tilapia have increased by at least 20% in 2001–2013 (Figure 19). By increasing stocking density, production per unit volume of water increases; thus, increasing total profits. The return on investment for a typical bamboo cage (5x10x2.5 m) and 2,000 fingerlings for stocking is 54%.[21] Increasing stock density

[21] BFAR Regional Office 02. http://region2.bfar.da.gov.ph/

Figure 19 **Retail Prices of Tilapia and Milkfish in the National Capital Region, Philippines, 2001–2013**



Sources: Bureau of Agricultural Statistics. *Fisheries Statistics of the Philippines,* various issues.

by 500 fingerlings will result in a return of investment of 75%, despite increasing feed costs and an assumed mortality of 80%. Thus, the enticement for overstocking is strong. As is the case in open access fisheries, all aquaculture operators are driven by the same profit-maximizing motive; and when governance is weak, such disasters are likely to occur. As in open access fisheries, the individual behavior of a fisher is consistent with rational economic behavior, but the aggregate effect threatens long-term profitability.

In cases like these, the simple economic framework used by a producer will not apply. First, the externalities of the farmer's behavior must also be accounted for, i.e., the impacts of aquaculture operations on the environment. Carrying-capacity studies must guide policy makers; and, as shown in the Bolinao case, such oceanographic parameters as tidal exchange and flushing rates must be considered when determining the number of licenses to be issued. Second, the opportunity costs of labor and capital should also be factored in. As pointed out earlier, the opportunity costs of dead fish actually feeding thousands of people and of borrowed operating capital could have been used elsewhere for productive purposes. Government costs for clean-up and cash for work also represent opportunity costs, which could have been used for other services had the fish kills not occurred. Lastly, costs are also incurred by other sectors that provide inputs (feeds, chemicals, and equipment) and forward linkages (transport and marketing) to the aquaculture sector. An economic framework that looks at externalities, opportunity costs, and costs incurred by forward and backward industry linkages is recommended as a tool to evaluate trade-offs associated with aquaculture operations.

F. Conclusion and Recommendations

The CTI RPOA does not contain much discussion about aquaculture, although coverage in the NPOAs is varied. Some countries (Malaysia and Timor-Leste) have dealt with aquaculture directly, while the others have treated aquaculture indirectly or as an independent concern. In general, pronouncements outside the CTI ambit view aquaculture as a strategy to address food security issues, malnutrition, rural incomes, export revenues, and employment. The CT-SEA and CT-Pacific countries have vastly different histories and approaches to aquaculture based on their respective resource endowments, overall economic thrusts, and population pressures. Aquaculture in CT-SEA countries is expected to continue expanding, with Indonesia still operating at below-capacity levels and the Philippines struggling to meet export standards and implementing good environmental management. Malaysia will continue its robust expansion phase, both for food security and export revenue generation. As Malaysia graduates into a high-income economy, a more discerning consumer base will require more product diversity, providing better nutrition and also sustainably farmed—and certified—products.

The CT-Pacific countries will experience high population growth, urbanization, and continuing shift from subsistence to cash economies. With inshore resources being depleted, the countries are now taking a serious but cautious stance toward aquaculture and have prioritized species and farming systems where the greatest impact can be expected at the least cost.

The resources required to support marine aquaculture, not to mention the indirect use of trash fish as a main component of fishmeal, are enormous. While aquaculture contributes to food and incomes, its development must not be pursued in a vacuum, especially when interactions with capture fisheries exist. By ignoring the threats posed by excessive use of fish protein as feeds, the objectives of both sectors may be unattainable in the long run.

Over the long term, all significant commercial seafood supplies and nonfood fish will come from one of three sources—fish farms and/or aquaculture; aquaculture-enhanced fisheries; and fisheries that adopt efficient management systems, highlighting the need for a more integrated approach toward capture fisheries and aquaculture.

This study, therefore, offers the following recommendations:

(i) As food security is one of the higher-level outcomes of the CTI, and aquaculture is used by countries as a strategy toward that end, issues related to aquaculture must be recognized and reflected in the RPOA, consistent with the EAFM approach. "For too long, fisheries and aquaculture have been treated as sectors in isolation, a practice that has ignored important linkages and externalities" (Williams 1996). After all, capture fisheries and aquaculture can occur in the same environments; require healthy supporting habitats such as mangroves and coral reefs; and are utilized by the same community. Foale et al. (2013) recommended that midway through the implementation period of the CTI, better articulation is required on how CTI intends to achieve the food security outcome, including how aquaculture is to contribute to this.

(ii) The role of aquaculture within the EAFM framework needs to be articulated to manage threats more effectively; and to recognize the potential contribution of aquaculture to sustainable resource management, as shown in the coral farming option and the suggested full-cycle culture of live reef fish. This can be communicated more effectively in future enhancements of the RPOA and NPOAs. CTI plans do not need to map out specific activities within the purview of aquaculture; instead, focus must be placed on policy harmonization and linkages.

(iii) A comprehensive valuation of the costs and benefits of aquaculture should be carried out with built-in scenarios associated with shocks (fish kills) and chronic and long-term influences (climate change). Economic literacy is essential in the locality and/or sites countrywide so that the impacts of fish kills and other environmental disasters associated with aquaculture are not trivialized. Costs and benefits associated with the utilization of trash fish as aquaculture inputs should also be analyzed with specific focus on the economic value of allowing juvenile fish occurring in cages to grow to marketable size. An article advocating for the ban on trawl fishing in Malaysia provided rough estimates on catches of *ikan kembong* (*Rastrelligerkanagurta*) and noted that at least 900 individuals made up 1 kg of trash fish. If allowed to grow to maturity, the same batch of trash fish would weigh 150 kg.

(iv) The CTI must be utilized as a forum for knowledge sharing on best aquaculture practices and those experiences that should not be emulated. The fish kill experiences of the Philippines can be instructional, especially as Malaysia prepares to expand mariculture of high-value species. The CTI can tap aligned institutional groupings, such as the Association of Southeast Asian Nations (ASEAN), the Southeast Asian Fisheries Development Center (SEAFDEC), and the Sulu–Sulawesi Marine Ecoregion (SSME), for knowledge sharing.

(v) Aquaculture commodities from the CTI can be marketed under a CTI standard or brand that conforms, at a minimum, to recognized best management practices such as the FAO Code of Conduct for Responsible Aquaculture. In addition, a specific agreement among the CT6 countries on a "special or unique" CTI standard can be forged. For example, in the tradition of fair standards, the CTI can brand aquaculture products from the community source and likewise provide some information on the use and/or disbursement of earnings.

(vi) Research on technologies to improve the feed conversion ratio for species requiring a large input of trash fish should be conducted. Applying more efficient technologies may require initial investments, but these could prove to be more efficient in the long run and decrease dependence on wild-caught trash fish. Likewise, technological improvements can also target value addition for trash fish to increase its economic value. Technological innovation is another option. For example, the Government of the Philippines supported the development of an underwater robot dubbed "Roboteknik" to serve as an early warning detection for fish kills, especially in freshwater lakes.

(vii) The aquaculture sector is showing signs of asymmetry in the availability of information related to resource use and governance, which could lead to economic and social inequality. In some cases, those with economic power can have greater access to such information, giving them a competitive advantage over other stakeholders (Cabral and Aliño 2011). This information can be used by those in power for discretionary decisions that benefit only few individuals, including themselves. Information of this nature is crucial, especially for tenure and access rights. The governments of the CT6 countries should promote equal treatment and provide greater access to the requisite information (e.g., through education, information campaigns, and consultations), and secure greater transparency in governance. Transparency implies participation of all stakeholders in planning land and marine use.

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IV. Connectivities in the Coral Triangle

Rollan C. Geronimo,[22] Lydia Napitupulu,[23]
and Annabelle C. Trinidad[24]

The Coral Triangle Initiative (CTI) is an opportunity for achieving synergies and outcomes. This is possible given that cooperative governance integrating social and ecological goals and objectives on a regional basis can redound to benefits greater than those that would be achieved by the CT6 countries. This chapter characterizes three layers of connectivity—ecological, economic, and institutional—and assesses opportunities for the CTI to be a robust and purposeful collaboration based on the strengths and weaknesses of these connections.

A. Ecological Connectivities

The Coral Triangle shares a globally unique characteristic—the most diverse coral reef ecosystems concentrated in a relatively small area of the world. This high biodiversity resulted from various evolutionary and ecological processes in synergistic environmental, oceanographic, and geological conditions that permitted the coexistence of thousands of species in patches and long stretches of coral reefs (Hoegh-Guldberg et al. 2009).

Ocean currents flowing through the Coral Triangle move plankton, larvae, propagules, nutrients, and even pollutants across the more than 26,000 islands of the CT6 countries, resulting in a complex web of sources and sinks for fish and other larvae (Kool et al. 2011, Treml and Halpin 2012).

Biophysical connectivity in the marine environment can refer to the following: (i) migration of animals between habitat patches; (ii) dispersal of larvae from spawning locations to downstream habitats; and (iii) flow of nutrients, sediments, and toxins from a watershed to an estuary. In areas with strong connectivities, resource management needs to be consistent and coordinated.

Using an individual-based larval dispersal model that integrates ocean current velocity data with larval settlement homing behavior, Kool et al. (2011) simulated the demographic connectivities of reef fish species in the Indo-West Pacific. They estimated the proportion of survivors from a given source population arriving at a designated destination, which allowed them to estimate the probability of populations being connected through time (Kool 2009, Kool et al. 2010). Demographic connectivity from their simulations shows a high overall level of self-recruitment

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[22] Research Assistant, ________.
[23] Junior Resource Economist, ________.
[24] Environmental Economics and Payment for Ecosystem Services Specialist/Team Leader.

throughout the Indo-West Pacific. Two-thirds of larvae that are able to settle on reefs do so within less than 120 kilometers (km) from their source reefs. However, there are notable connectivities across the Indo-West Pacific. Protecting the connectivity matrixes over time resulted in three distinct blocks representing clusters of larval exchange in the Indo-West Pacific: (i) certain areas in the South China Sea; (ii) the reefs of the western part of the Coral Triangle between the Java–Sulu Archipelago and the Bismarck–Banda Sea, and the eastern portions of the Banda Sea; and (iii) between the reefs of Papua New Guinea and Solomon Islands.

Complementing and corroborating the work of Kool and colleagues (2011), Treml and Halpin (2012) developed separately a larval dispersal model for the Coral Triangle region extending up to the South China Sea, Australia, Japan, and other Pacific island countries, and territories north and south of the Coral Triangle boundary. Factoring all rare or weak dispersal connections, they predicted that all the Coral Triangle reefs are evolutionarily connected. However, applying more stringent thresholds of probabilities to account only for ecologically relevant connectivities, they also identified hotspots where reef habitats are strongly connected by dispersal in the Coral Triangle. These hotspots include the east coast of Sumatra in Indonesia along Karimata Strait, the South China Sea–Sulu Sea–Visayan Sea band across the Philippines, Sabah, and Tawi-Tawi corridor of Malaysia and the Philippiines, central Indonesia from Makassar Strait to the Flores Sea, Halmahera Sea, and the southern islands of PNG (Treml and Halpin 2012).

Treml and Halpin (2012) analyzed the larval dispersal connectivity patterns in networks across countries, ecoregions, and seascapes in and around the Coral Triangle. This approach allowed them to relate larval dispersal patterns and strengths of connectivity to conservation planning units. The larval dispersal pattern across the CT6 countries is relatively linear with a dominant west to east pattern of connectivity. The reefs of the Coral Triangle Southeast Asia (CT-SEA) countries consistently come out as a hotspot of larval dispersal connectivity. Indonesia's central role in larval dispersal and ecologically connecting the Coral Triangle is also highlighted. Papua New Guinea (PNG) and Solomon Islands are further downstream in the larval dispersal pathway, acting primarily as regional sinks for coral reef fish and coral larvae.

Tuna. The archipelagic diversity of habitats in the Coral Triangle also makes it a prime refuge for juvenile yellowfin and bigeye tuna (Bailey et al. 2012b). Tunas are highly migratory species and the CT6 countries overlap in the populations of tuna that they exploit (Morgan and Valencia 1983). Different species of tuna move in and out of the Coral Triangle and are caught at varying stages of development by different countries across the region. Juvenile tunas are caught in the waters of Indonesia and the Philippines. These are often sold in domestic markets or canned, making their value much less than that of adult tuna caught in the Pacific island countries, often by international fishing fleets from developed countries. Ingles and Pet-Soede (2012) called this phenomenon the "Broken Triangle" because of the mismatch of benefits in the tuna fishery in relation to expected fisheries management inputs.

As of 2010, countries that serve as habitats for juvenile tuna receive the least benefit from the tuna supply chain since juvenile tuna prices are much lower than those of adult tuna. However, these countries (e.g., Indonesia and the Philippines) are often expected to implement stricter tuna fishing regulations to sustain the regional tuna fisheries. In the Philippines, 54% of 266,200 t of tuna caught are juveniles. The proportions of juveniles by species in the total catch are: 92% bigeye, 88% yellowfin, and 38% skipjack. Because countries exploit different stages and sizes of tuna based on availability (i.e., increasing in size from the Philippines to Indonesia to PNG), sweeping management measures on tuna fisheries in the region would be difficult to implement because some countries would be adversely affected more than others (Bailey et al. 2012b). Mechanisms to increase the incentives for these countries to regulate juvenile tuna fishing are urgently needed, and the distant fleets from developed countries that benefit most from the tuna stocks in these areas should proportionately assist and support management of tuna fisheries in the region.

The coastal habitats of Indonesia, Malaysia, and the Philippines are important feeding grounds for juvenile tuna, while adult and larger tuna species are caught in PNG and Solomon Islands. Tuna spawning grounds in the CT-SEA countries need to be protected, and catching of juvenile tuna regulated. This requires support mechanisms that involve the CT6 countries and foreign fleets catching adult tuna in the Pacific. These foreign tuna fleets are the primary beneficiaries of improved protection of juvenile tuna in Southeast Asia.

Marine turtles. Various species of marine turtles nest in the Coral Triangle (Pilcher 2009). Olive ridley turtles nest in Puerto Princesa in Palawan, Philippines. Green and hawksbill turtles nest in great numbers both in the Turtle Islands Heritage Protected Area in Malaysia and the Philippines, and in the Berau District Marine Conservation Area in Indonesia (Pilcher 2009). Marine turtles, such as leatherback and green turtles, migrate extensively across the Coral Triangle and beyond (Pilcher 2009, Block et al. 2011, Bailey et al. 2012a).[25] Leatherback turtles (*Dermochelys coriacea*) nesting in Indonesia travel to different foraging areas in the South China Sea, particularly along the coast of Palawan in the Philippines, the seas in Indonesia, and southeastern Australia, reaching as far as the western coast of the United States (Bailey et al. 2012a). Green turtles move across the entire Coral Triangle. Local management actions protecting nesting areas, and reducing harvests of turtle eggs and adults, can reduce the extinction risk for turtles (Dethmers and Baxter 2011). Besides protecting turtle nesting areas, countries also need to collectively reduce the bycatch of turtles from longlines and drift nets to ensure the resilience of turtle populations across the Coral Triangle.

Coral reefs. In the Coral Triangle, coral reefs and fishery resources are connected. Although there is some connectivity across the countries in terms of larval dispersal of coral reef organisms, demographic connectivity of coral reefs in the Coral Triangle is largely limited to self-recruitment (Kool et al. 2011, Treml and Halpin 2012). This implies that, for coral reefs and associated fisheries, local conservation efforts in each Coral Triangle country are urgently needed. However, larval dispersal models still reveal important larval sources and sinks in the region that require a networked and integrated approach to management to be regionally effective. Coral reefs in the Coral Triangle located along country boundaries are most likely close enough to rely on each other for larval supply.

Despite being dominated by self-recruitment, centrality in larval connectivity still exists in the Coral Triangle, with Indonesia serving as an important node connected to most Coral Triangle countries in terms of larval supply, even if limited (Treml and Halpin 2012). Thus, improvements in coral reefs in Indonesia could have significant downstream effects on other Coral Triangle countries; it must, therefore, set a good example of coral reef conservation and management to the rest of the CT6 countries. However, since Indonesia also receives larvae from PNG and the

[25] WWF. http://www.worldwildlife.org/what/wherewework/coraltriangle/species.html

Philippines (Kool et al. 2011), these countries must conserve and maintain the ecological viability of their coral reefs for Indonesia to sustain its coral reef and fisheries diversity.

The CT6 countries are also ecologically connected to other countries in the Indo-West Pacific and Australia. The South China Sea, particularly the Spratly Islands, may be an important source of genetic diversity for the Coral Triangle. As this area is not isolated, management must eventually engage other countries outside the Coral Triangle.

Three ecologically connected clusters in the Coral Triangle have been repeatedly cited in larval dispersal studies: (i) Indonesia, Malaysia, and the Philippines; (ii) PNG and Solomon Islands; and (iii) Indonesia and Timor-Leste. Therefore, implementing fisheries management actions in the Coral Triangle region may be done using these ecologically relevant clusters.

B. Economic Connectivities: Trade in Fisheries Products

Economic connectivities can take many forms, including trade in goods and services, transport, currency, factors of production, infrastructure, and institutions. These connectivities exist in the Coral Triangle, with some links stronger than others. International trade, in particular, allows the movement of goods and services. Goods embody the inputs and/or factors used in their production; and can, therefore, be a proxy in the movement of factors of production.

Seafood consumption is rapidly growing on a global scale. Annual per capita consumption of fishery products has grown steadily in developing regions from 5.2 kilograms (kg) in 1961 to 17.0 kg in 2009 (FAO 2012). This is, however, still lower than the demand from Oceania where annual per capita fish consumption is 24.6 kg, North America at 24.1 kg, and Europe at 22.0 kg. Most of the fish consumed in these developed regions are imported, and demand for fish continues to rise. To meet this increasing demand, developing countries have increased their own production (including through aquaculture), but have also resorted to importing some of their needs from other countries. Consequently, seafood is now one of the most highly traded commodities in the world.

Developing countries are increasingly supplying fish to developed countries, accounting for up to three-quarters of merchandise exports in some countries (ICTSD 2006). Also, economic growth in developing countries has made them a lucrative market for products from developed countries. Export markets for fish contribute substantially to the increasing value of raw materials. Fish reexport industries (e.g., fish processing and canning) are also important sources of employment in the CT6 countries and add value to fishery resources.

One of the most compelling theories to describe the pattern of international trade was developed in the 1930s by Eli Heckscher and Bertil Ohlin (more popularly referred to as the Heckscher-Ohlin Model), in which they linked resource endowments and trade patterns (Krugman and Obstfeld 2012). The factor proportions theory indicates that countries will export goods that intensively use locally abundant resource endowments, and import goods that intensively use less locally abundant resource endowments (Krugman and Obstfeld 2012). As described in Chapter II, the CT6 countries possess uniformly rich marine biodiversity and fisheries resources that are reinforced through biological connectivities between them, which also influence fish trading patterns between and among the CT6 countries and between them and the global markets.

1. Fisheries Trade among CT6 Countries

The CT6 countries have open economies whose fishery products are also traded in the international market, although in varying quantities across the region. The Philippines exports only 7% of its total fish production, while PNG and Solomon Islands export more than half of the catches from their domestic fleets (Table 17). Asia and Oceania have marked differences in the volume of their fish exports relative to total domestic fish production, with Oceania exporting almost 60% of its total domestic production. These regional patterns are also reflected in the CT6 countries.

Table 17 Fishery Exports and Imports in CT6 countries, 2007

Country	Total Fish Production (t)	Live Weight (t)		Quantity as % of Total Production	
		Total Export	Total Import	Export	Import
Indonesia	6,443,241	896,599	80,516	14	1
Malaysia	1,563,942	359,848	514,614	23	33
Papua New Guinea	263,960	143,207	28,355	54	11
Philippines	3,209,410	215,023	176,232	7	5
Solomon Islands	31,272	17,282	2,744	55	9
Timor-Leste	350	...	...	...	...
Asia (excluding the People's Republic of China)	44,551,175	9,856,804	10,366,289	22	23
Oceania	1,414,234	830,650	553,310	59	39

... = data not available, t = ton.
Source: Laurenti (2012).

Timor-Leste, the youngest country in the group, has relatively scarce trade data since most of its trade is unrecorded. A very small volume of exports was recorded in 2005 in the form of processed and/or dried fish (606 kg valued at $2,722), and no official fisheries export was recorded between 2006 and 2010. However, in 2012, Timor-Leste started exporting again (Alda Sousa Lemos da Rosa, personal communication, 3 April 2012). In 2005, the recorded fishery imports were about 104 tons (t) with a total value of about $264,000, composed mostly of processed fish and related commodities (UN Comtrade n.d.). In 2008, fishery imports for fish and crustaceans, mollusks, and other aquatic invertebrates (Harmonized System category 03) totaled $249,000 in 2008, rising to $622,000 in 2010 (DNE n.d.).

The volume of trade in fish and fishery products among the CT6 countries is not large compared with trade with countries outside the Coral Triangle (Table 18). In 2000–2008, there appeared to be a trade surplus for Indonesia and PNG; and a trade deficit for Malaysia, the Philippines, and Solomon Islands. For the Coral Triangle as a region trading with the rest of the world, there was a consistent surplus from 2000 to 2008, which has increased by about 60% or an average of 7.5% increase per year. However, this rate of increase is barely above the world average inflation rate of 7.3% for that period.[26] Therefore, the value has been more or less stagnant in real terms.

[26] Calculated from the World Bank's inflation database. http://data.worldbank.org/indicator/FP.CPI.TOTL.ZG

Table 18 Net Value of Fishery Products Trade between the CT6 Countries and the Rest of the World ($ million)

Country	2000	2001	2002	2003	2004	2005	2006	2007	2008
Indonesia	18.89	28.54	35.12	26.19	24.09	26.85	25.64	41.76	35.92
Malaysia	(50.54)	(69.74)	(58.26)	(53.91)	(52.94)	(55.12)	(55.74)	(72.85)	(71.75)
Papua New Guinea	5.71	10.98	(0.02)	10.92	12.37	...	...	...	...
Philippines	(7.68)	(1.75)	(5.86)	(19.10)	(5.80)	(18.79)	(16.48)	(18.29)	(25.55)
Solomon Islands	...	...	(0.31)	(0.05)	0.03	0.02	(0.01)	(0.39)	...
CT6 with the Rest of the World	1,897	1,862	1,870	2,000	2,056	2,115	2,247	2,531	3,043

( ) = negative or deficit, indicating imports in excess of exports; ... = data not available.

Note: Total value from FAO data, including trade of fishes, crustaceans, mollusks, and other aquatic animals, but excluding aquatic mammals, crocodiles, caimans, alligators, and aquatic plants.

Source: Data provided by Stefania Vanuccini, fishery statistician (Commodities), FAO Fisheries and Aquaculture Statistics and Information Service.

Based on bilateral fish trade flows for 2010 from the UN Comtrade database, dependence of the CT6 countries on each other, in terms of exports or imports, ranged from less than 0.1% (i.e., for exports from Solomon Islands) to 26.1% (for exports from PNG). The major trading partners in terms of relative contribution to the country's export or import values were Indonesia–Malaysia and the Philippines–PNG (Table 19). Almost 20% of the import value for fish in Malaysia came from Indonesia. However, exports to Malaysia constituted only 2.7% of Indonesia's total fisheries exports. Malaysia also exported fish to Indonesia, contributing 8% to Indonesia's total fisheries

Table 19 Percentage Contribution of Fish Exports and Imports between and among CT6 Countries by Value

Partner Countries (Destination or Source)	Exporter (%)					Importer (%)			
	Indonesia	Malaysia	Papua New Guinea[a]	Philippines	Solomon Islands	Indonesia	Malaysia	Philippines	Solomon Islands
Indonesia		4.2	0.1	0.3			**18.1**	3.4	
Malaysia	2.7			0.2		8.0		0.4	0.2
Papua New Guinea[a]		<0.1		<0.1	<0.1			**13.3**	<0.1
Philippines	0.2	0.3	**25.9**			0.3	0.1		
Solomon Islands	<0.1		0.1						
Timor-Leste	<0.1								
% of CT6 contribution	3.0	4.4	26.1	0.4	<0.1	10.1	18.2	17.0	0.2

[a] Except for Papua New Guinea, which is in tons.

Notes:

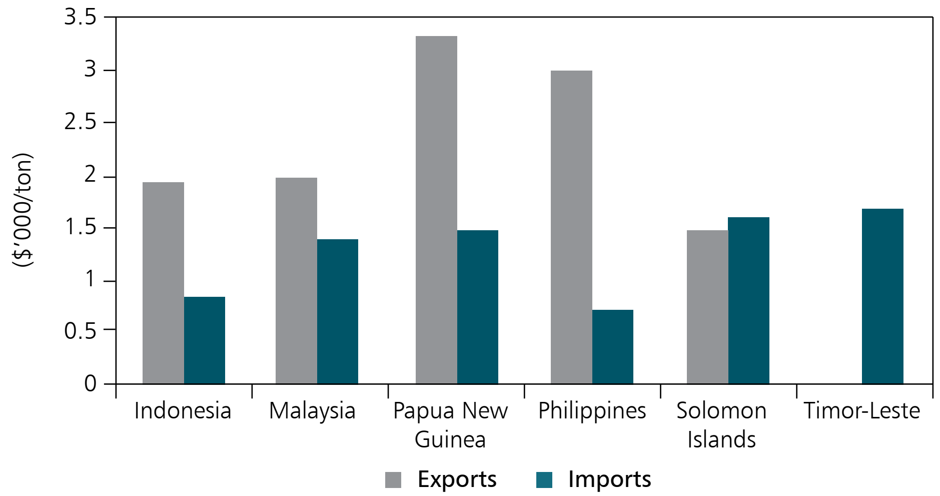
1. Values greater than 10% are highlighted by bold font and gray shading.
2. Export data for processed and frozen tuna and other species are based on quantity (tons).

Source: Usu (2011).

import value. The Philippines, also a major export market for PNG, comprised a quarter of the total fish export value for PNG. This amount was equivalent to 13.3% of the total fish import value for the Philippines. Overall, the CT6 countries are more important to each other as suppliers to augment domestic fish supply than as major export markets. Relative to overall import values, fish coming from other CT6 countries contributed between 0.2% and 18.2% of total fish import values for a given CT6 country. The CT6 countries comprised at least 10% of total fish import values for Indonesia, Malaysia, and the Philippines. In contrast, as export markets, the CT6 countries contributed not more than 5% to total fish export value, except for PNG and the Philippines.

The value of fishery trade products per ton relates to the overall quality of fish products traded. PNG and the Philippines export high-value fish products, primarily tuna, with an average value of $3,000–$3,300 per ton (Figure 20). The Philippines imports the lowest-value fishery products, primarily low-value food fishes and non-human consumption feeds, reflected in the per unit average value of imports of less than $1,000 per ton. The Philippines also has the largest difference between export and import values per ton of fishery products; for Solomon Islands, they are almost at par; and Timor-Leste showed almost no export of fish products to other countries.

Figure 20 **Value of Fishery Imports** (per ton) **and Exports per Coral Triangle Country, 2009**



Note: Includes "fish" commodity only per FAO classification.
Source: FAO (n.d.).

2. Fisheries Trade between CT6 and Other Countries

The CT6 countries are net exporters of fish to countries outside the region. Overall, their net annual marine fishery exports to other countries are valued at $3 billion (Table 20). In 2010, the major export commodities were shrimps and prawns in various forms and stages of processing, accounting for 46% of the combined fish export value of Indonesia, Malaysia, and the Philippines. In 2010, tuna was also a major export commodity, accounting for 11% of total value of fish export products from the CT6 countries.

Table 20 **Top Export (and Reexport) Partners of CT6 Economies, 2010**

CT6 Export Destination	Weight (kg)	Value ($)	Value/Weight ($/kg)
Thailand	216,738,567	112,912,904	0.52
People’s Republic of China	151,066,883	122,800,221	0.81
Japan	119,201,544	685,059,985	5.75
US, Puerto Rico, and US Virgin Islands	110,391,435	705,879,470	6.39
Singapore	88,759,019	171,200,743	1.93
Viet Nam	50,250,418	96,312,281	1.92
Other Asia, not elsewhere specified	45,522,714	73,608,888	1.62
Hong Kong, China	42,112,298	218,939,507	5.20
Malaysia	41,820,707	45,220,784	1.08
Indonesia	37,668,682	29,378,242	0.78

kg = kilogram, US = United States.
Source: Data from UN Comtrade (n.d.).

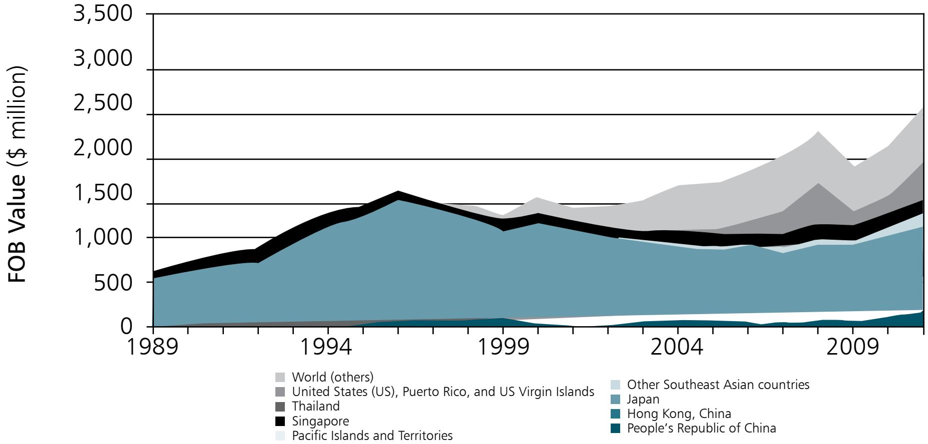
CT6 trade increased in quantity and value during 1989–2011 (Figure 21). In 2010, CT-SEA countries imported 0.7 million t valued at $0.9 billion and exported 1 million t of fish products valued at $2.7 billion (UN Comtrade n.d.). Six destination economies accounted for 70% of the total export of fish and fishery products by weight from the CT6 countries (Table 21). In addition, Hong Kong, China, a major trading partner for the live reef food fish trade, received 4% of the total fish products exported by the CT6 economies.

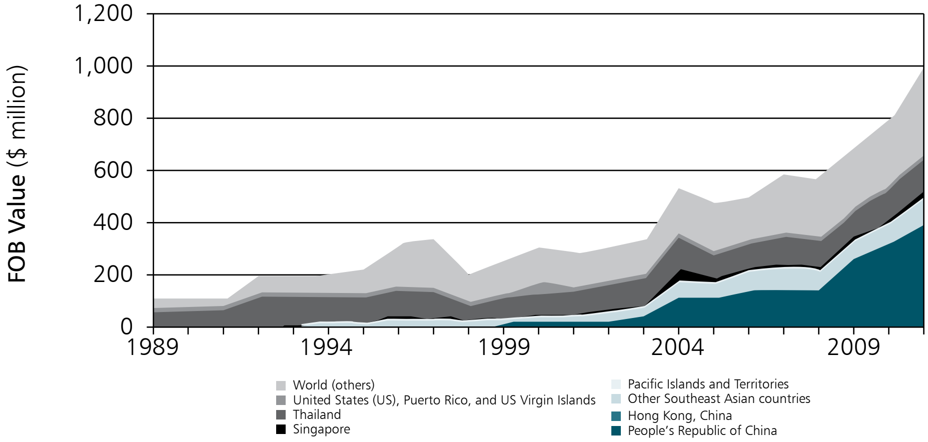
In terms of value, three economies (the United States [US], in the amount of $705.9 million; Japan, $685.1 million; and Hong Kong, China, $218.9 million) accounted for more than 70% of the total value of exports from CT6 countries, while comprising only 30% of total weight (Table 20). These are the higher-value exports from the CT6 countries, averaging $5–$7 per kg compared with less than $2 per kg to other countries. The US, Japan, and Hong Kong, China—together with the People’s Republic of China (PRC), Singapore, Thailand, and Viet Nam—accounted for 93% of the total export value and 86% of the total weight of fish products from the CT6 countries.

The role of each Coral Triangle country as a trading partner for some economies is shown in Table 21, which indicates Japan and the US as the major exporting destinations for Indonesia, Malaysia, and the Philippines; while the PRC is a major import source for these three CT-SEA countries. The European Union is an important export destination for PNG, the Philippines, and Solomon Islands. For most countries, however, exports from the CT6 countries do not constitute a major share of their total exports.

Some 17 economies and/or regions depend on CT6 countries for a major portion of their fisheries imports, comprising 5% or more of total imports (Figure 22). At the top of the list is Yemen, where 35% of imports are from the CT6 countries, followed by Singapore at 32%. To assess the position of CT6 countries in seafood exports for various commodity groupings, Table 22 shows their rankings among the world’s top 10 exporters for each commodity group. The CT-SEA countries are among the top 10 producers in the world. For live fish, Indonesia, Malaysia, and the Philippines are consistently top world producers for several commodities, including fresh live fish, eel, carp, and whole (fresh or chilled) Salmonidae, flatfish, yellowfin tuna, skipjack and other

Figure 21 **Aggregate Free-On-Board Values of Fish Trade from CT6 Economies, 1989–2011**





Source: UN Comtrade (n.d.).

tunas, and eel. The CT-SEA countries are also top producers for some frozen seafood categories, including Pacific salmon, Salmonidae, yellowfin, albacore, longfin, and other tunas, as well as dogfish, eel, and seabass. Note that unlike the live exports, only Indonesia—not Malaysia and the Philippines—is the strong player in world exports for frozen seafood.

For processed fisheries commodities, only Indonesia is among the Top 10 producers of fish fillets, cured, and/or smoked fish; and fishmeal for human consumption. For prepared seafood, CT6 countries are among the top 10 producers in very few commodities. This points to possible opportunities to expand domestic value-adding activities in the CT6 countries (taking into account production costs and constraints) that could further create jobs and generate income.

The CT6 countries are important in marine ornamental fish trade. In 2005, the Philippines and Indonesia were the largest exporters of marine ornamental fish to the US; each represented over 990 species while in the number of fishes, the Philippines represented 5.8 million, and Indonesia

Table 21 **Percentage Contribution of Fish Exports and Imports of CT6 Economies with Other Economies by Value**

Partner Economy	Exporter					Importer			
	Indonesia	Malaysia	Papua New Guinea[a]	Philippines	Solomon Islands	Indonesia	Malaysia	Philippines	Solomon Islands
Coral Triangle	3.0	4.4	**26.1**	0.4	<0.1	**10.1**	**18.2**	**17.0**	0.2
Outside Coral Triangle									
PRC	3.7	6.1		3.1		**38.4**	**32.5**	**21.5**	1.9
Japan	**28.3**	**12.6**	7.9	**23.6**		8.9	2.8	9.8	**11.6**
Other SEA	2.9	6.4	0.6	0.6	<0.1	9.2	9.0	**10.5**	
Pacific Islands and Territories	<0.1	0.1	5.5	0.9	0.1	0.5		1.5	
Singapore	3.9	**15.2**	2.0	2.5		1.2	0.8	2.1	<0.1
Thailand	4.4	3.3	3.9	1.9	**62.5**	**12.9**	**14.3**	0.4	**27.3**
Australia	0.8	4.4	7.7	0.2	0.1	0.6	1.2	0.2	**37.3**
Hong Kong, China	5.1	9.2		**15.8**	1.3		0.6	0.1	1.0
New Zealand	<0.1	0.2	0.1	<0.1		0.4	0.8	0.7	**20.7**
Other Asia, nes[b]	2.2	3.1	3.3	5.0		3.8	1.6	**16.4**	
United States	**30.5**	**23.1**	7.7	**20.1**	0.2	1.9	1.0	4.5	
Europen Union	8.4	2.9	**33.7**	**15.1**	**35.7**	0.3	1.5	0.4	
World (others)	6.8	9.2	1.5	10.8		11.8	15.6	14.9	<0.1

PRC = People's Republic of China, nes = not elsewhere specified, SEA = Southeast Asia.

[a] Except Papua New Guinea, which is in tons; values greater than 10% are highlighted by bold font and gray shading.

[b] "Other Asia nes" is a classification from the UN Comtrade database; it includes Taipei,China.

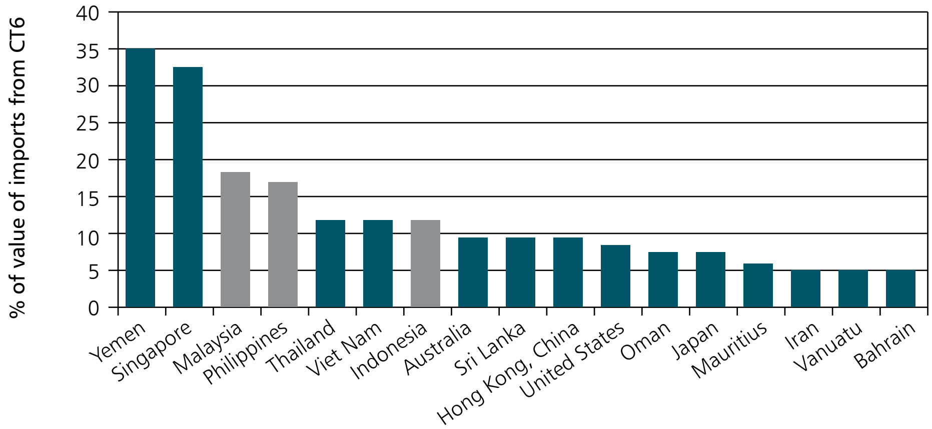
Source: Usu (2011).

3.3 million fishes (Rhyne et al. 2012). Solomon Islands also exported marine ornamental fish to the US, but contributed only 1% to the total imports of marine ornamental fishes. Four Coral Triangle countries are sources of corals for the coral trade: Indonesia, Malaysia, the Philippines, and Solomon Islands. The Philippines leads in volume, but Indonesia leads in value. These four countries accounted for 27% of the volume and 38% of the value of corals imported by the US during 1996–2011 (UN Comtrade n.d.).

C. Governance and Institutional Linkages

The CT6 countries are signatories to several binding and nonbinding agreements (Fidelman and Ekstrom 2012). There are strong regional ties between and among Indonesia, Malaysia, and the Philippines, separate from PNG and Solomon Islands (Table 23; Figure 23). Timor-Leste, being a new independent nation, is involved in the Partnerships in Environmental Management

Figure 22 **CT6 Economies' Value of Fishery Imports**



Data source: UN Comtrade using the commodity code HS1996.03 (accessed 6 November 2012).

for the Seas of East Asia (PEMSEA), and voluntarily implements the Regional Plan of Action (RPOA) for Responsible Fishing. Of the 19 fisheries-related agreements, Indonesia, Malaysia, and the Philippines have the highest membership among the CT6 countries. Five of the CT6 countries are signatories to INFOFISH, the RPOA for Responsible Fishing, and the Asia-Pacific Group of Fisheries and Aquatic Research (GOFAR). INFOFISH, headquartered in Kuala Lumpur, is an intergovernmental organization that provides marketing information and technical advisory services to the fishery industry of Asia and the Pacific and beyond. With the inclusion of Timor-Leste, INFOFISH can serve as a technical support organization for the fisheries of the CTI. The CT6 countries are also signatories to the Convention on Biological Diversity. Except for Timor-Leste, the five other countries are also signatories to the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES).

The institutions could be grouped into (i) regional fisheries bodies, which focus solely on fisheries management concerns; and (ii) regional cooperation initiatives with fisheries as one of the areas of interest (Table 24). Two functional and influential geopolitical and economic organizations—the Association of Southeast Asian Nations (ASEAN) and the Asia-Pacific Economic Cooperation (APEC)—provide opportunities for integrating the aspirations and vision of the CTI into broader regional and global economic agenda.

ASEAN is a geopolitical and economic organization of 10 countries in Southeast Asia, including Indonesia, Malaysia, and the Philippines. Both PNG and Timor-Leste have been applying for membership into ASEAN since 1976 and 2002, respectively. Of particular relevance to the Coral Triangle is the ASEAN Wildlife Enforcement Network (ASEAN-WEN), which was set up to counter illegal cross-border trade of endangered flora and fauna. ASEAN-WEN has external links with enforcement agencies in Australia, the PRC, the European Union, and the US; and with the secretariats of ASEAN and CITES, Interpol, and the World Customs Organization. To advance the regional goals of the CTI, several communities within ASEAN are of relevance, including the ASEAN Ministerial Meeting on Agriculture and Forestry and the ASEAN Ministerial Meeting on

Table 22 **Top 10 World Exporters in Some Fresh Seafood Categories, 2010**

Harmonized Coding System Code/Product Description	Top 10 Exports (Leftmost = Top 1)									
0301 Fish, live										
Fish	Malaysia	Spain	Philippines	Thailand	Indonesia	Greece	Sri Lanka	Myanmar	United Kingdom	People's Republic of China
Eel	People's Republic of China	Indonesia	Myanmar	Denmark	The Netherlands	Philippines	Hong Kong, China	New Zealand	France	United Kingdom
Carp	Czech Republic	People's Republic of China	Lithuania	Iran	Hungary	Malaysia	United States	Bosnia Herzegovina	Croatia	Belarus
Fish, except trout, eel or carp	People's Republic of China	Malaysia	Philippines	Republic of Korea	Thailand	Myanmar	Indonesia	Japan	Hong Kong, China	United States
0302 Fish, fresh or chilled, whole										
Salmonidae, not trout or salmon	Norway	Panama	Indonesia	Mauritania	Morocco	Thailand	India	Turkey	Greece	France
Flatfish, not halibut/plaice/ sole	United States	Indonesia	United Kingdom	Spain	France	The Netherlands	Ireland	Denmark	Egypt	Pakistan
Tuna (Yellowfin)	Indonesia	Thailand	Philippines	Japan	Panama	Sri Lanka	Maldives	Mexico	Fiji	France
Skipjack, Stripe-bellied bonito	Oman	Spain	United States	India	Fiji	Italy	Greece	France	Portugal	Indonesia
Tuna not elsewhere specified	Indonesia	Viet Nam	Malta	Spain	Croatia	Fiji	Turkey	Australia	United States	Portugal
Eel	Indonesia	Denmark	United Kingdom	The Netherlands	Sweden	Iran	United States	People's Republic of China	Belgium	Spain

continued on next page

Table 22 *continued*

Harmonized Coding System Code/Product Description	Top 10 Exports (Leftmost = Top 1)									
0303 - Fish, frozen, whole										
Salmon, Pacific	United States	Chile	Russian Federation	Japan	Fiji	Mauritania	Canada	People's Republic of China	Mexico	Indonesia
Salmonidae, not elsewhere specified	Mauritania	Indonesia	Norway	United States	Thailand	Burkina Faso	Pakistan	India	Viet Nam	Cambodia
Flatfish except halibut, plaice or sole	United States	Pakistan	Indonesia	Russian Federation	The Netherlands	Spain	Republic of Korea	Iran	India	Ecuador
Tuna (albacore, longfin)	United States	Japan	South Africa	Fiji	Singapore	Canada	Spain	Indonesia	Republic of Korea	New Zealand
Tunas (yellowfin)	Republic of Korea	Spain	France	Philippines	Colombia	Mexico	Thailand	Indonesia	Fiji	Cape Verde
Skipjack, stripe-bellied bonito	Republic of Korea	Japan	France	Indonesia	People's Republic of China	Ecuador	Maldives	Colombia	New Zealand	Brazil
Tuna not elsewhere specified	Republic of Korea	Viet Nam	Spain	Ecuador	Fiji	People's Republic of China	Indonesia	Australia	United States	France
Dogfish and other sharks	Spain	Japan	Singapore	United States	Portugal	New Zealand	Viet Nam	Indonesia	Costa Rica	Republic of Korea
Eel	United States	People's Republic of China	New Zealand	Canada	Iran	Malaysia	Thailand	Indonesia	Denmark	India
Seabass	Malaysia	Hong Kong, China	Singapore	Nicaragua	Belgium	The Netherlands	Thailand	United States	Turkey	Portugal

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Table 22 *continued*

Harmonized Coding System Code/Product Description	Top 10 Exports (Leftmost = Top 1)									
0304 - Fish fillets, fish meat, mince except liver, roe										
Fish fillets, frozen	People's Republic of China	Viet Nam	Norway	United States	Argentina	Germany	Iceland	Chile	The Netherlands	Indonesia
Fish meat and mince, except liver, roe and fillets, frozen	United States	Norway	Viet Nam	Iceland	Thailand	People's Republic of China	Chile	Indonesia	Argentina	New Zealand
Flours, meals, and pellets of fish for human consumption	United States	Thailand	South Africa	Pakistan	People's Republic of China	Myanmar	Indonesia	Russian Federation	Spain	Malaysia
0305 - Fish, cured, smoked, fishmeal for human consumption										
Livers and roes, dried, smoked, salted or in brine	People's Republic of China	Indonesia	Iceland	Canada	United States	Denmark	Norway	Hong Kong, China	Malaysia	Viet Nam
Smoked fish and fillets other than herring or salmon	Thailand	Indonesia	Denmark	Poland	Turkey	Chile	The Netherlands	Philippines	People's Republic of China	Estonia
Cod dried, whether or not salted but not smoked	Norway	Sweden	Iceland	Portugal	People's Republic of China	Spain	Denmark	Indonesia	Russian Federation	Canada

continued on next page

Table 22 *continued*

Harmonized Coding System Code/Product Description	Top 10 Exports (Leftmost = Top 1)									
Dried fish, other than cod, not smoked	Norway	Thailand	People's Republic of China	United Republic of Tanzania	Viet Nam	Iceland	Hong Kong, China	Indonesia	Myanmar	Maldives
Herrings, salted or in brine, not dried or smoked	Denmark	The Netherlands	Norway	Russian Federation	Indonesia	Germany	Estonia	Ireland	Canada	Lithuania
Fish not elsewhere specified, salted or in brine, not dried or smoked	Hong Kong, China	Canada	Norway	Iceland	Pakistan	Latvia	United Kingdom	Indonesia	Spain	Ethiopia
1603 - Extracts, juices of meat, fish, aquatic invertebrates	Italy	People's Republic of China	Thailand	United States	India	Brazil	France	Malaysia	The Netherlands	New Zealand
1604 - Prepared or preserved fish, fish eggs, caviar										
Sardine, brisling, sprat prepared/ preserved, not minced	Malaysia	Thailand	Latvia	Ecuador	Ukraine	United States	Estonia	Indonesia	Portugal	People's Republic of China
Tuna, skipjack, bonito, prepared/ preserved, not minced	Thailand	Philippines	Ecuador	Spain	Mauritius	Indonesia	People's Republic of China	Guatemala	Viet Nam	The Netherlands

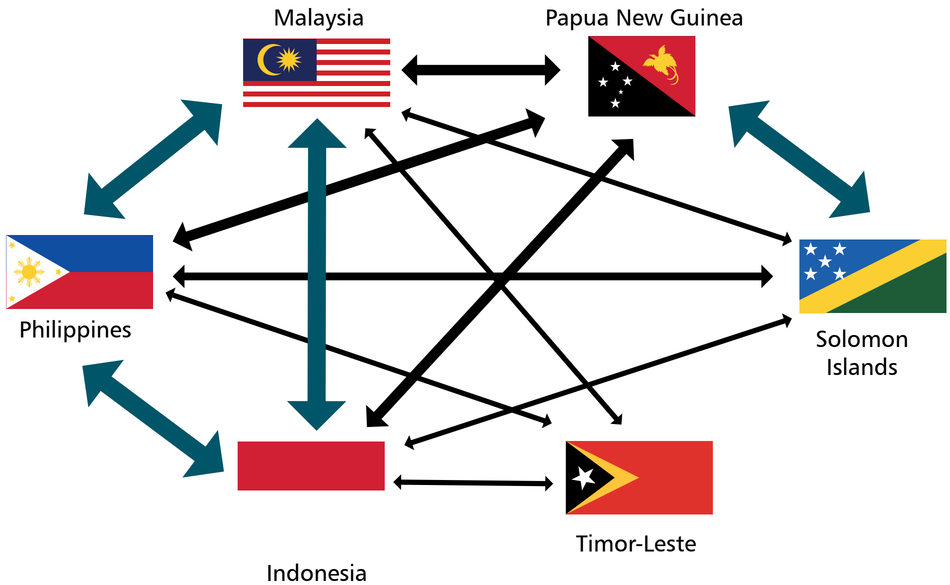
Source: UN Comtrade (n.d.).

Table 23 **Number of Multilateral Fisheries-Related Agreements among CT6 Countries**

	Indonesia	Malaysia	Philippines	PNG	Solomon Islands	Timor-Leste
Indonesia		13	11	4	2	2
Malaysia	13		11	4	2	2
Philippines	11	11		5	4	2
PNG	4	4	5		9	
Solomon Islands	2	2	3	9		9
Timor-Leste	2	2	2			
Total	**32**	**32**	**32**	**22**	**17**	**15**

PNG = Papua New Guinea.
Source: Data from Table 24.

Figure 23 **Binding and Nonbinding Fisheries-Related Agreements among CT6 Countries Showing Overlaps**



Note: Arrow thickness indicates relative number of fisheries agreements between countries. Blue in RSCTR arrows refer to relationships with more than 11 existing agreements.
Source: Data from Table 23.

the Environment. To scale up the investment climate in the CTI, the ASEAN economic ministers, ASEAN finance ministers, and ASEAN Investment Area Council can be linked with existing initiatives in the CTI such as the Regional Business Forum and the initiatives of the Financial Resources Working Group.

APEC consists of 21 member economies including four of the CT6 countries.[27] Its members account for over 80% of global aquaculture production and more than 65% of the world's

[27] Solomon Islands and Timor-Leste are not members.

Table 24 Regional Fisheries Institutional and Governance Agreements among CT6 Countries

Institutional Arrangements		Description	Indonesia	Malaysia	Philippines	Papua New Guinea	Solomon Islands	Timor-Leste	Coral Triangle Issues
			Countries Involved						
Regional Fisheries Bodies	Regional FMOs	IOTC: Indian Ocean Tuna Commission	✓	✓					Tuna
		WCPFC: Western and Central Pacific Fisheries Commission	C		✓	✓	✓		Tuna
	Fisheries Advisory Bodies	APFIC: Asia-Pacific Fishery Commission	✓	✓	✓				Tuna
		FFA: Forum Fisheries Agency				✓	✓		Tuna
		SEAFDEC: Southeast Asian Fisheries Development Center	✓	✓	✓				Tuna; LRF; IUU
Regional Arrangements/Cooperation/Networks/Projects	Scientific Bodies	INFOFISH: Intergovernmental Organization for Marketing Information and Technical Advisory Services for Fishery Products in the Asia-Pacific Region	✓	✓	✓	✓	✓		
		NACA: Network of Aquaculture Centers in Asia-Pacific	✓	✓	✓				
		SPC: Secretariat of the Pacific Community				✓	✓		
	Economic Cooperation	APEC: Asia-Pacific Economic Cooperation	✓	✓	✓	✓			Tuna; IUU
		ASEAN: Association of Southeast Asian Nations	✓	✓	✓	O		O	Endangered species
		PIF: Pacific Islands Forum				✓	✓		
	Fisheries/Environmental Arrangements	BOBLME: Bay of Bengal Large Marine Ecosystem Project	✓	✓					
		COBSEA: Coordinating Body on the Seas of East Asia	✓	✓	✓				
		CTI: Coral Triangle Initiative	✓	✓	✓	✓	✓	✓	
		PEMSEA: Partnerships in Environmental Management for the Seas of East Asia	✓	✓	✓			✓	
		PSAP: Strategic Action Program of the Pacific Small Island Developing States				✓	✓		
		RPOA: Regional Plan of Action for Responsible Fishing	✓	✓	✓	✓		✓	
		SCS: UNDP/GEF South China Sea Project	✓	✓	✓				
		SPREP: Secretariat of the Pacific Regional Environment Programme				✓	✓		
	Scientific Networks	GoFAR: Asia-Pacific Group of Fisheries and Aquatic Research	✓	✓	✓	✓	✓		

C = collaborating nonmember; FMO = fisheries management organization; IUU = illegal, unreported, and unregulated; LRF = live reef fish; O = observer status.

Notes:

1. The last column corresponds to Coral-Triangle-relevant fishery issues or topics that can be covered by a corresponding agreement.
2. Prepared by Christine Marie Casal (WorldFish Center Philippines).

Sources: Lymer et al. (2010); and on colaborating nonmembers, the Western and Central Pacific Fisheries Commission. http://www.wcpfc.int/

capture fisheries; and the consumption of fishery products in the APEC region is 65% higher than the world average.[28] Thus, APEC economies are an important voice internationally on fishery-related issues; and, collectively, have a significant impact on the global sustainability of fisheries and fish trade. APEC established the Oceans and Fisheries Working Group in 2011, representing a merger of the Marine Resource Conservation Working Group and Fisheries Working Group. The Oceans and Fisheries Working Group announced that it was initiating a mapping study of all fisheries initiatives within APEC, as well as developing a work plan during the APEC Senior Officials Meeting held in Indonesia in February 2013.

The Southeast Asian Fisheries Development Center (SEAFDEC) is an intergovernmental organization established in December 1967 for promoting sustainable fisheries development in the region. Its member countries include Indonesia, Malaysia, and the Philippines. Of interest to the CTI is SEAFDEC's collaborative activity to update scientific information and the status of tuna resources in the Sulu–Sulawesi Sea, a priority seascape of the CTI; and its project on preventing export of illegal, unreported, and unregulated (IUU) fishing products. SEAFDEC led the CT6 countries to establish a live reef fish forum as a result of a conference held in February 2013 in Bangkok. SEAFDEC's mandate in marine fisheries research and aquaculture may well cover issues relating to the exploitation of juvenile groupers, wrasses, and other fish species, the impacts on ecosystems and fish of lower trophic levels and the requirements for full-cycle culture of such species.

The agreements among the CT-SEA countries are more economic in nature, while those among CT-Pacific countries have strong knowledge-sharing components. The Secretariat of the Pacific Community (SPC) and the Pacific Fisheries Forum Agency (FFA) are highly technical agencies able to provide sound scientific advice to member countries in the development of their fisheries. The FFA includes PNG and Solomon Islands plus 15 other Pacific island countries. It is an advisory body providing expertise, technical assistance, and other support to its members, which make sovereign decisions about their tuna resources and participate in regional decision making on tuna management through agencies such as the Western and Central Pacific Fisheries Commission (WCPFC). The FFA's focus on tuna can be explored further, especially in sustainable financing initiatives such as payment for ecosystem services. The Secretariat of the Pacific Regional Environment Programme (SPREP) has networks on climate change, invasive species, and biodiversity, and it can form useful links to the CTI.

A big challenge in the CTI is building stronger relationships within the CT6 countries. While multilateral and bilateral fisheries-related agreements abound among the CT-SEA countries and among the CT-Pacific countries, agreements between them are few. The CTI is the first nonbinding agreement that encompasses all CT6 countries and could serve as a platform for linking CT-SEA and CT-Pacific countries in view of their shared unique attribute—high coral reef biodiversity.

There are opportunities for the CTI to strengthen partnerships with existing institutions, such as through exchange of knowledge between organizations or standardization of policies and procedures, for example. ASEAN-WEN practices can be extended to the CT-Pacific countries, especially those relating to exportation of corals. There are existing organizations involved in tuna in terms of actual management and supporting science work that span all CTI countries;

[28] APEC. http://www.apec.org

however, a purposeful connection should be planned. SEAFDEC has the potential to address several important issues, including tuna, live reef fish, and IUU fishing, and has signified interest in engaging with CT6 countries in the live reef fish trade.

D. Conclusions

Ecological connectivities in the Coral Triangle are robust compared with their economic and institutional connectivities, for which more planned actions can be pursued. As coral reefs are largely self-recruiting, locally focused conservation efforts in each Coral Triangle country are urgently needed. The migration of iconic species such as turtles, and high-value species like tuna, suggests where cooperation can be strengthened. Centrality in coral and fish larval connectivity also exists, with Indonesia serving as an important node connected with most of the CT6 countries in larval supply. Improvements in coral reefs in Indonesia could have significant downstream effects in the other CT6 countries.

Trade within the CT6 countries is less significant than trade between them and the global markets. This explains their similarity in fisheries resource endowments. The resource-rich CTI countries have great opportunities for global trade, especially with the continuing decline of fishery resources in developed countries. Recent evidence has shown an easing of exploitation rates in some of the well-studied fisheries in developed countries. Yet, over half of the assessed fish stocks in developed countries still require rebuilding (Worm et al. 2009, Hutchings et al. 2010).

In addition to exploring opportunities for value addition, the CT6 countries could increase their trading advantage by forming a bloc to maximize market strength toward greater concentration and standard pricing, niche pricing, and product differentiation. Using the industrial performance framework, the CT6 countries would have more advantage as a CTI entity supplying goods and services to global markets than as individual countries acting on their own. Cooperative undertakings forged through CTI can increase market strength such as pricing agreements, and developing niche markets for a range of unique products (horizontal and vertical product differentiation), which is possible because of the high biodiversity of fish species in the region (Table 25).

Table 25 **Advantages of the CT6 Countries Acting as a Bloc in Fisheries Trade**

Selected Elements of Market Structure and Conduct	Advantage
Concentration	Increased market strength with possible pricing agreement
Product differentiation	CT6 countries boast of 2,500 species of fish alone, such enormous biodiversity making vertical and horizontal differentiation highly possible
Barriers to entry	Agreement on a common pricing strategy; and a common policy, to limit entry into overfished areas within national boundaries, and to control fish supply
Pricing	Agreement on pricing range and niche pricing, especially for certified commodities
Advertising	Marketing of “CTI” as a brand

Source: Authors.

The idea of economic integration is not new. To accelerate the region's economic integration by 2015, ASEAN has identified 11 priority sectors,, one of which is fisheries (*Pomeroy* et al. 2008). To increase intra-ASEAN trade, several integration criteria were agreed upon such as tariff and nontariff barriers, improvement of logistics, rules of origin, and movement of human resources. Accordingly, the fisheries road map toward integration specifically targeted food safety issues. The ASEAN model can be used as a springboard on which to design a CTI-type integration.

Product differentiation involving the production of more value-adding products with countries participating at various nodes of the supply and/or value chain can enhance trade opportunities among CT6 countries. However, an in-depth study on factor prices (e.g., labor, natural endowments, and capital) and opportunities for supply and/or value chain specialization nodes is required.

Applying the same principles of connectivity as in ecological linkages, institutional linkages can be optimized for knowledge sharing, application of similar standards, and transfer of technology. Subregional nodes, such as that of Southeast Asia and the Pacific, can be utilized to establish institutional affiliations. Common interregional issues, such as migrating stocks of tuna or trade in live reef fishes, are examples of where institutional linkages can be strengthened, and can illustrate how the CTI can achieve its broad objectives by leveraging existing institutions and not attempting to address issues alone, which could be ineffective and wasteful of resources.

The CTI is very timely, given the recognition of the region's importance in global coral reef biodiversity, fisheries, and food security from marine resources. While it is the first agreement entered into by all six countries, multilateral coordination mechanisms and agreements on fisheries and coastal and marine resources management in the region already exist, albeit fragmented. The CTI is an opportunity to synchronize and integrate these various arrangements toward more targeted management of coral reefs and fisheries in the region for improved food security and well-being. Furthermore, as knowledge on fisheries in the Coral Triangle is largely scattered, increased interaction and collaboration between and among regional fisheries agencies and organizations can ensure that the regional goals of the CTI, particularly for fisheries, are achieved.

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V. Subsistence Fisheries in the Coral Triangle

Annabelle C. Trinidad,[29] Rollan C. Geronimo,[30] Joelle Albert,[31] Lydia Napitupulu,[32] Delvene Boso,[33] Johannes Subijanto,[34] Christine Marie Casal,[35] Orlando Halek Kalis,[36] Celestino da Cunha Barreto,[37] Fidelino Sousa Marques,[38] and Lino de Jesus Martins[39]

A. Overview

Globally, the numbers of small-scale fishers and their fisheries are "too big to ignore" (Chuenpagdee 2012).[40] Béné (2003) and the Food and Agriculture Organization of the United Nations (FAO 2010b) estimated more than 34 million active fishers. Berkes et al. (2001) estimated over 50 million fishers supporting at least 450 million dependents. In contrast, large-scale fisheries employ about 500,000 fishers (Béné 2003; FAO 2010b). Small-scale fisheries contribute half of the global fish supply for human consumption (Jacquet and Pauly 2008). While commercial fisheries contribute $3 billion annually to the CT6 countries (Hoegh-Guldberg et al. 2009), 2 million artisanal fishers depend on the region's coastal reefs and mangroves for subsistence and income (Weeratunge et al. 2011).

There are varied definitions of "small-scale fisheries," depending on the points of view and socioeconomic dimensions interpreted in different national and local contexts (Johnson 2006). Small-scale fisheries are usually contrasted with large-scale fishing operations using technological parameters. Tokeshi et al. (2012) stated that "coastal fisheries in tropical countries are typically small-scale, involves (sic) small boats and gear, operated by one or a small number of fishers and less selective in terms of species caught compared to most coastal fisheries in mid to high latitudes."

Johnson (2006) proposed the values of social justice and ecological sustainability as defining small-scale fisheries. WWF, in an unpublished report entitled "Small Boats, Big Problems,"

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29 Footnotes 21, p. 43; and 27, p. 63.
30 Footnotes 3, p. 5; and 25, p. 63.
31 WorldFish Center, Solomon Islands.
32 Footnote 26, p. 63.
33 Country Manager, WorldFish Center, Solomon Islands.
34 Knowledge Integrator.
35 Database Specialist.
36 Staff, Ministry of Agriculture and Fisheries, Timor-Leste.
37 Footnote 39, p. 85.
38 Footnote 39, p. 85.
39 Footnote 39, p. 85.
40 "Too Big to Ignore" is the title given to a Global Partnership for Small-Scale Fisheries Research as a forum for collaborative research, policy dialogue, and advocacy on issues pertinent to small-scale fisheries around the world.

argued that small-scale fisheries do not necessarily imply technological inferiority or spatial limitation in terms of spheres of exploitation, and they are not necessarily excluded from international trade.[41] Further, small-scale fisheries are not necessarily sustainable because they are characterized by overcapacity and use of destructive methods, especially in weak governance regimes.

The FAO glossary defines small-scale fisheries as

> …traditional fisheries involving fishing households (as opposed to commercial companies), using relatively small amount of capital and energy, relatively small fishing vessels (if any), making short fishing trips, close to shore, mainly for local consumption. In practice, definition varies between countries, e.g., from gleaning or a one-man canoe in poor developing countries to more than 20-m trawlers, seiners, or long-liners in developed ones. Artisanal fisheries can be subsistence or commercial fisheries, providing for local consumption or export. They are sometimes referred to as small-scale fisheries.[42]

Small-scale fisheries include artisanal, recreational, and subsistence, which is defined as "a fishery where the fish caught are shared and consumed directly by the families and kin of the fishers rather than being bought by middle-(wo)men and sold at the next larger market" (FAO and WorldFish Center 2008). Sowman (2006) described subsistence fishers as "those fishers who are poor, fish mainly for food and may exchange or sell surplus harvest to meet other basic needs."

In both definitions, subsistence fishing contains three elements: (i) relatively small volume of fish caught per trip, (ii) local consumption as the primary use of fishes caught, and (iii) opportunistic selling or bartering of surplus harvests. This suggests there are no pure subsistence fisheries because virtually all fisheries are integrated into markets through opportunistic selling.

The ambiguity and intractability of subsistence fisheries pervade the Coral Triangle Initiative (CTI) member countries. In Malaysia, for example, Nasir (2001) defined small-scale, artisanal, and subsistence as follows:

(i) "Small-scale fisheries are undertaken using small-scale boat, gear, and equipment.
(ii) Artisanal fisheries are undertaken mostly for home consumption using selected traditional gear.
(iii) Subsistence fisheries are undertaken mainly for home consumption using selected traditional gear."

In Indonesia, although there is no formal and legal definition of small-scale fisheries, the sector is accorded special mention in government codes and ministerial decrees (Nikijuluw 2001). Fisheries Act No. 31/2004 defines an artisanal fisher as anyone who relies on fishing as one's livelihood to meet one's daily needs (Sularso 2008). The definition of small-scale fisheries is widely understood by scientists, academics, bureaucrats, and politicians to mean fisheries undertaken by ordinary people in contrast to fisheries done by formal fishing enterprises. Sularso (2008) characterized Indonesia's artisanal fisheries as 1-day fishing, using traditional fishing gears and/

[41] See or download the report from http://wwf.panda.org/?132341/small-boats-big-problems

[42] FAO Fisheries and Aquaculture Department. Small-scale and artisanal fisheries. http://www.fao.org/fishery/topic/14753/en

or a motorized boat with a maximum of 5 gross tons (gt), fishing within 12 nautical miles of the coastline, and with the catch mostly for the domestic market. The three major fishing gears used in artisanal fisheries are hooks and lines (39.1%), gill nets (27.8%), and traps (10.9%).

In Papua New Guinea (PNG), subsistence fishing is characterized by harvesting using traditional or low-technology inputs. Artisanal fishing is differentiated as fishing where the harvest is sold for cash income, generally at local markets with some postharvest technology employed, such as smoking for preservation. Artisanal fishing involves the catching of seabasses, lobsters, shallow-water reef fishes, nearshore pelagic fishes, mangrove crabs, freshwater prawns, and a range of other reef and coastal fishes (Kailola 1995). Fish account for 94% of consumed animal protein in Solomon Islands with nearshore subsistence fishing meeting 60% of consumption needs (Weeratunge et al. 2011).

In Malaysia, Teh and Sumaila (2011) estimated that Sabah's small-scale catches have been undervalued by up to 225% since the early 1990s. In Solomon Islands, 82% of the population belong to rural and coastal communities, of which at least one adult per household is involved in fishing. In the Philippines, there are more than 1.3 million small-scale fishers as compared with 16,000 in the commercial sector. In Indonesia, there are more than 2.3 million fishers, including both part-time and full-time fishers (Nikijuluw 2001).

Subsistence fisheries contribute significantly to poverty alleviation, food security, and incomes as measured through gross domestic product (GDP). In a recent review of benefits from Pacific island fisheries, the Asian Development Bank (2009) estimated the contribution of subsistence fishing to GDP to be quite large in a number of Pacific island countries. Overall, about 30% of GDP contribution from the fishing sector in the region came from subsistence fishing (Gillett 2011). Coastal subsistence fisheries were estimated to contribute 84% of the overall fisheries production from coastal areas in PNG in 2007; and 82% in Solomon Islands (Gillett 2011). Gillett (2009) estimated the value of reef fish in Solomon Islands at $12 million per year. Brewer (2011) recomputed that value based on varying prices and markets and estimated the value of reef fisheries at $21 million.

Employment and livelihood statistics also highlight the significance of this sector. In the Pacific island countries, for example, coastal subsistence fisheries accounted for only 11.9% of the total regional coastal and marine fisheries value in 2007 despite subsistence fishers outnumbering formally employed fishers at 10:1 (Gillett 2009).

Subsistence fisheries are given attention in this report in recognition of the issues summarized by the FAO that they are underreported, undervalued (economically), "notoriously" difficult to manage, and not fully considered in the development dialogue. As a subset of the already underestimated and weakly evaluated small-scale fisheries, regular monitoring of the subsistence fisheries sector is almost nonexistent.

To contribute to the knowledge of subsistence fisheries in the CT6 countries, this study used various methodologies to assess the importance of subsistence fisheries in contributing to incomes, jobns, and food security. In Solomon Islands and Timor-Leste, the approach was to use surveys to obtain primary information on subsistence fisheries and dependency levels. In the Philippines, a workshop involving national and local government agencies mandated for fisheries data collection was organized. This approach aimed to assess the current methodologies for data collection on subsistence fisheries sector by examining how national agencies undertake their collection protocols, and determining how data collection is undertaken from information supplied by representatives of local governments.

In Timor-Leste, a survey of capture fisheries households in Liquica District (Suco Dato) was conducted in May to July 2012 to (i) obtain the extent of dependency by households on fisheries-related activities for their livelihoods in the villages; and (ii) enhance the capacity of the Ministry of Agriculture and Fisheries (MAF) to design, plan, and implement a national fisheries household census. This project recognized the opportunity to assist in the conduct of a planned national census of fisheries households[43] by functioning as a "pilot test" for the larger census and providing training to the MAF staff. Timor-Leste's national plan of action (NPOA), particularly Target 4, which supports livelihood and food security programs using the ecosystem approach to fisheries management (EAFM) and integrated coastal management approach, is the overall guidance document for this study. In particular, Action 1.4.1 intends to map fishery-dependent communities.

B. Fisheries and Reef Interactions in Solomon Islands

The discussion in this report on the importance of the subsistence sector in Solomon Islands was derived largely from Albert et al. (2012), in the study "Economic Valuation of Coral Reefs and Development of Sustainable Financing Options in Solomon Islands."[44]

1. Background

Solomon Islands has a dual economy: (i) formal or cash; and (ii) informal or subsistence, which includes the vast majority (85%) of the population. Agriculture, fishery, forestry, and small-scale income-generating activities form the bulk of subsistence economy. The literature in Trinidad et al. (2012) emphasizes the importance of subsistence fisheries in Solomon Islands in contributing to food, nutrition, jobs, and cash incomes. However, estimates of production from the sector and related statistics are mostly guesswork (FAO 2010a). Household income and expenditure surveys provide a "best estimate" of catches associated with the subsistence sector (FAO 2010a). Green et al. (2006) observed that while it is easy to monitor the amount of catch that goes through provincial fisheries centers and marine product buyers in urban areas like Honiara, Auki, or Gizo, the largest portion goes unmonitored through public fish markets in urban areas and private sales. Household consumption of fish, particularly in rural communities, is not properly accounted for, except through household expenditure surveys.

Coral reefs are very important in the lives of Solomon Islands residents both for subsistence and income generation. Reef fish contributes significantly to the protein intake of the population (Bell et al. 2008), and is also becoming an important source of income with increasing access to markets (Green et al. 2006). Some differences in food fish populations among the major islands

[43] Refers to households that engage in fisheries-related activities including aquaculture, capture fisheries, fish processing, and marketing.

[44] The research study was conducted by ADB technical assistance for Regional Cooperation on Knowledge Management, Policy, and Institutional Support to the CTI (TA 7307-REG); and the WorldFish Center, with funding from Australian Aid and administered by the Australian Department of Sustainability, Environment, Water, Population and Communities as part of the Australian government's support program for the CTI.

are attributed to the combined effect of variation in coral reef habitat and the impact of human activities, particularly fishing. Green et al. (2006) observed that the healthiest populations of food fishes are in areas where few people live.

This report contributes to the understanding of the importance of subsistence fisheries in Solomon Islands using information generated by the study of Albert et al. (2012), the *State of the Coral Triangle Report* by Sulu et al. (in press), and related literature. In particular, the study by Albert et al. (2012) provides estimates of the volume and value of reef-derived goods, including fish, trochus, shells, and corals in four rural coastal communities.

2. Coastal Subsistence Fisheries in Solomon Islands

Gillett (2010) listed six categories of fisheries use in Solomon Islands: (i) coastal commercial, (ii) coastal subsistence, (iii) offshore: locally based, (iv) offshore: foreign-based, (v) freshwater, and (vi) aquaculture. Coastal subsistence fishing involves fishing in nearshore waters, mainly in reefs, using dugout canoes, simple hooks and lines, spears, or simply gleaning. Catches from offshore foreign-based fishing—mainly tuna—are at least five times larger than catches from coastal subsistence fishing (Table 26). Finfish, bêche-de-mer, trochus, green snail, and mangrove wood are among the commodities coastal fishers harvest. Data from FAO statistics for the production of fish, crustaceans, and mollusks yield estimates up to 2010 but do not provide the same disaggregation.[45] The average volume in 2008–2010 was about 30,000 tons (t), which conforms to the offshore: locally based fishing figure in Table 26. Data on offshore: foreign-based fishing, although conducted in Solomon Islands waters, are reflected in the countries of the fleets.

There are no figures on the extent of fishing activity in the country, as well as on subsistence fishing. However, nearly half of all women and 90% of men in most rural households are estimated to fish (Weeratunge et al. 2011). Nearly all households in coastal villages are involved in coastal fishing activities. Thus, all villages in Solomon Islands that are rural and coastal are "fishing communities." The number of subsistence fishers in Solomon Islands can be crudely estimated by looking at the total population—about 570,000 in 2012—and assuming 82% as the rural population. By dividing this by the average number of household members in rural households, estimated by the Secretariat of the Pacific Community as 5.2 persons, the minimum number of subsistence fishers was derived. A minimum of 88,000 people are estimated to be

Table 26 **Marine Fisheries Production in Solomon Islands, 2007**

Type of Fishing	Volume (ton)	Value ($)
Coastal commercial	3,250	3,307,190
Coastal subsistence	15,000	10,980,392
Offshore: locally based	23,619	32,662,077
Offshore: foreign-based	98,023	153,548,868
Total	**139,892**	**200,498,527**

Source: Gillett (2010).

[45] FAO Yearbook of Fishery Statistics. ftp://ftp.fao.org/fi/stat/summary/default.htm

engaged in fishing, assuming one household member is a fisher. This, however, is a conservative estimate. If the inputs of women and other adult men are considered in the estimate, the number of subsistence fishers would double to 175,000.

The estimates are significant when compared with the total population but more so when compared with fish workers or those who are formally employed. In 1999, an estimated 3,367 people were engaged in paid work in the fisheries sector, accounting for 12.1% of total paid employment in Solomon Islands (Weeratunge et al. 2011).

3. Fish Consumption

Solomon Islands has one of the highest per capita fish consumption rates in the world. Bell et al. (2009) estimated that the average annual per capita fish consumption in urban areas was 45.5 kilogram (kg) and 31.2 kg in the rural areas, while the national average was 33 kg (90% consisted of fresh fish). However, these figures may be an underestimation (Weeratunge et al. 2011) since Pinca et al. (2009) estimated annual per capita fish consumption between 98.6 kg and 110.9 kg.

Among urban households, average expenditure on fish in 2005–2006 (for food consumption) was slightly higher than the national average of 14.5%, while rural households spent 13.0% (Table 27). Rural households rely on their own production or that of their kin and/or community members for more than half of their fish requirements. Urban households rely minimally (5%) on their own production. At least 16% of all households in Solomon Islands are either self-employed or participate in activities that have upstream or downstream links with fisheries such as marketing, processing, and transporting. Most rural fishers sell their catch when their household needs dictate it (Suluet al. in press). Honiara is one of the major markets, although there are markets at provincial centers, including Auki (Malaita), Gizo and Munda (Western provinces), Kirakira (Makira), Tulagi (Central Islands Province), and even as far as Bougainville for nearby communities (Boso et al. 2009).

4. Case Study: Economic Value of Subsistence Fisheries

ADB's technical assistance, Regional Cooperation on Knowledge Management, Policy, and Institutional Support to the Coral Triangle Initiative Project, and the WorldFish Center in Solomon Islands collaborated on a study on coral reef valuation to inform policy on resource uses and values, profile international trade in corals, and assess future support to coral farming as an alternative to current forms of extraction (Albert et al. 2012, Trinidad et al. 2012). Primary data in four communities was collected in the Western and Central provinces. Two communities were selected in the Western Province to represent those with no known wild coral harvest (non-coral trade communities). Two communities were also selected in the Central Province to represent areas with a known history of wild coral harvesting for the aquarium and curio trade (referred to collectively in this report as "coral trade" communities). All four communities harvested coral for the production of lime, which is consumed while chewing betel nut. The reef environments included mostly fringing reefs, with some deeper and barrier reefs. Using Google Earth, the total reef area was estimated at 0.13 square kilometers (km^2) and 0.50 km^2 for the Central Island Province reefs, and 7.00 km^2 and 0.82 km^2 for the Western Province reefs.

Table 27 **Fish Utilization in Solomon Islands, 2005–2006** (%)

Source	Urban	Rural	National
Food consumption expenditure on fish	16.9	13.0	14.5
Home production[a]	4.8	55.9	36.9
Households with self-employed members and engaged in businesses related to the sale of fish and other seafood	9.3	16.4	15.9

[a] Refers to the value of goods and services produced by the household to be predominantly consumed by the same household or given as gifts.

Sources: Solomon Islands National Statistics Office. Household Income and Expenditure Survey (2006); and Sulu et al. (in press).

Structured questionnaires and focus group discussions (FGDs) were used to collect data on the uses of coral reef resources. Of the respondents, 92 were in the Central Island provinces and 60 in the Western provinces. Other population parameters for the four communities are shown in Table 28.

Total economic value framework was used to estimate direct, indirect, and nonuse values of corals. Direct use values refer to products and services directly consumed (extractive and non-extractive) while, for the purpose of this study, indirect values refer to the coastal protection function of coral reefs. In this report, only direct values associated with subsistence fishing are discussed.

The direct use values of coral reefs to rural coastal communities were derived by asking respondents the (i) type of food goods (including fishes, clams, crayfishes, shells, and seaweeds); (ii) construction materials (sand, rubble, and coral boulders); and (iii) trade goods (e.g., trochus, shark fins, coral limes, curio corals, aquarium corals, and other reef ornamentals) they collect from the reefs. Respondents were further queried on the quantities collected and the importance of each food goods for their food and cash needs. Community-level economic values of coral reef goods were derived through FGDs, from the community leaders (men and women) at the time of the interviews.

Table 28 **Number of Interviews Undertaken in Case Study Communities in Solomon Islands and Population Parameters**

Community	Number of Respondents (Male/Female)	Total Population	Population (Aged >14)	Number of Households
Coral Trade Communities in the Central Island Province				
Central Island Community A	40/23	693	393	93
Central Island Community B	17/12	384	237	55
Non-Coral Trade Communities in the Western Province				
Western Community C	24/12	1,193	744	158
Western Community D	15/8	468	274	65

Source: Albert et al. (2012).

Table 29 Value of Food, Material, and Trade Goods at the Four Study Communities in Solomon Islands
(SI$ per respondent per year)

	Coral Trade Communities		Non-Coral Trade Communities	
Item	Community A	Community B	Community C	Community D
Food	9,619	32,683	42,920	17,778
Reef fish	3,419	7,749	12,062	8,197
Materials	533	14,224	1,884	1,061
Trade	8,312	28,236	3,608	2,385
Total	18,464	75,143	48,412	21,224

Notes:
1. Reef fish values are shown separately.
2. The exchange rate in November 2011 was $1 = SI$7.28.
Source: Albert et al. (2012).

Coral reefs provided from SI$18,000 to SI$75,000 per respondent per year (Table 29). Food contributed the greatest proportion to the total economic value of direct-use goods at all sites (Albert et al. 2012). Food goods derived from reefs yielded subsistence and cash value ranging from SI$9,600 to SI$43,000 per respondent per year across the four study sites. Fish was considered by all communities as the most important reef good and accounted for 23%–39% of the total direct economic value at the two "non-coral trade" harvest communities and 10%–18% at the two "coral trade" communities.

The value of reef fish ranged from SI$3,400 to SI$12,000 per respondent per year across the four study sites, with the community with the largest reef area deriving the highest value (Table 30). Using an estimate of 88,000 people involved in fishing and extrapolating from the four villages, the subsistence and cash value of reef fish was estimated at SI$300 million–SI$1,000 million per year ($41 million–$145 million per year).

These results highlight the importance and value of reef fish for both subsistence and cash needs for rural coastal Solomon Island communities. These estimates are 4–13 times greater than the value of coastal subsistence fisheries estimated by Gillett (2011), and suggest that the value of

Table 30 Total Value of Reef Fish for Subsistence and Cash at Study Sites in Solomon Islands (SI$ per respondent per year)

Site	Subsistence Value	Cash Value
Community A	3,419	470
Community B	7,749	1,064
Community C	12, 062	1,650
Community D	8,197	1,125

Source: Albert et al. (2012).

reef fish to rural communities may have been undervalued earlier and that more accurate data on the subsistence value of reef fish in the country are needed. To further contextualize the magnitude of underreporting, the value of subsistence fisheries was compared with per capita income, which was estimated at $3,200 for 2011[46] or roughly SI$22,857. In the absence of appropriate values for the subsistence economy, it was assumed that real per capita income can be adjusted upward using the value of the contribution of subsistence sector at the minimum, noting that other reef goods make a similar contribution. The upward adjustments to per capita income range from a minimum of 11% to a maximum of 28%.

C. Capture Fisheries in Timor-Leste

In the late 1990s, when political turmoil ravaged Timor-Leste (at the time, still a province of Indonesia), most fisheries infrastructure were destroyed, including fishing vessels and gear (Kalis 2010). A 2001 survey estimated only about 800 seaworthy vessels, while Indonesia's last record before the turmoil listed 20,027 wooden canoes and 160 motorized vessels (McWilliams 2003). Only in the mid-2000s was a systematic development of the fisheries sector possible, including the recording of fisheries data. In 2005, close to 5,000 fishers in 151 fishing centers in the country were reported. By 2009, 6,360 people were reported, with 2,177 nonmotorized and 615 motorized vessels (Kalis 2010). A national boat census taken in 2011–2012 registered 2,865 boats nationwide, of which 1,324 were issued licenses (FAO 2012).

The Government of Timor-Leste has strengthened collection of fisheries data through the conduct of a fisheries census including a boat census, which was completed in October 2012 with the assistance of FAO. For this report, a survey of capture fisheries households in Liquica District (Suco Dato) was conducted in May–July 2012 to (i) obtain the level of dependency of village households on fisheries-related activities for their livelihoods; and (ii) enhance the capacity of the Ministry of Fisheries (MAF) to design, plan, and implement a national fisheries household census. The survey was funded by ADB technical assistance for Regional Cooperation on Knowledge Management, Policy, and Institutional Support to the Coral Triangle Initiative Project, and was administered by UNIQUEST (Australia).

1. Survey of Fishing Households

A household survey was conducted in May–July 2012 in two coastal villages, Camalehohoru Aldeia, and Leopa in the Liquica District, Dato subdistrict, about 50 kilometers (km) west of Dili, the capital. In 2010, Dato had a total population of 8,109 with 1,221 households (average size of 6.7 persons). Of this total, Camalehohoru Aldeia and Leopa had 5,075 persons in 764 households, for an average household size of 6.6 persons (NSD and UNFPA 2011).

More than half of the households (56%) fished every day; the remainder fished 2–5 days per week (41%) or one day per week or less (19%). Almost all catches were sold or consumed fresh. The average monthly revenues from selling the harvested fish were $1,282 (May), $175 (June), and $216 (July), all in 2012.[47] The average total cost of fishing during the May–July 2012

[46] See www.indexmundi.org

[47] June, July, and August are poor fishing months in the survey area.

period was $263; hence, an average net income of $1,410 for 3 months, or $470 per month. However, there were wide income differences among fishers—from a low loss of $266 to a high revenue of $1,248.

A large proportion of households surveyed (24%–75%) also depended on other agriculture-related activities, including crop planting and livestock keeping. However, 53% said that fishing was their main source of livelihood.

Based on the FAO and WorldFish (2008) nomenclature of categories of fishers, the survey respondents fulfill most of the criteria for subsistence fisheries, with two exceptions: (i) the disposal of catch because the survey respondents' catch was primarily for sale, with a portion for domestic and/or own consumption; and (ii) the households were integrated into the economy since most of the fishing and disposal took place via market channels.

Overall, the profiles indicate the dominance of subsistence fishing, with some larger-scale and more commercial fishing activities (Table 31). Large variability existed in catches across the households surveyed. The household with the highest gross revenue—$11,510 for 3 months—had three motorized boats—two medium-sized and one small; and fishing was their main source of income. In contrast, the income of the lowest grossing, regular fishing household was $130 over 3 months, although fishing was not the main source of household income.[48]

2. Community Dependency

A village census of all households within a prescribed area was also conducted in Aldeia Mane Mori in the Ulmera District to enumerate those households with at least one member engaged in capture fisheries, aquaculture, or salt harvesting. Mane Mori is a small village near Dili with a narrow mangrove-lined beach. Households in the community were engaged in various of ocean-related activities such as capture fisheries, seaweed farming, aquaculture (grouper grow-out and crab collecting and grow-out), and salt harvesting. Official Aldeia records indicated 60 households, although the census found 62, of which 59 were available for interview.

The census showed that over half of the households interviewed 33 or 56% had no members engaged in capture fisheries or aquaculture. At least one member in 18% of the households engaged in capture fisheries, and 25% in aquaculture. Four households (7%) had at least one member engaged in both capture fisheries and mariculture. Overall, community dependence on fisheries was high—about half of the households were dependent for their livelihood on the sector.

Dependence on fisheries as a source of livelihood varied. It was the main source of income for those engaged in aquaculture (11 households). All households indicated fisheries as their main source of income, although they could not attribute the percentages to either aquaculture or capture fisheries. They indicated, however, that aquaculture provided a more stable source of income than fishing.

48 The main sources of income sources were growing garden fruits and vegetables and raising livestock.

Table 31 **Categories and Characteristics of Fisheries in Timor-Leste**

Characteristics	Subsistence Fisheries[a]	Survey (May to July 2012)		Regional or National[b]	
Size of fishing craft/vessel and engine	None or small (5–7 meters; <10 gross ton) usually nonmotorized	62% of households operate small or medium (up to 7 meters) nonmotorized boats; 50% of households operate small or medium motorized boats (up to 15 horsepower); and only 3% (one household) uses a large boat (>7 meters).	✓	78% of vessels are without engine (2009) in a regional survey in five districts; 82% use wooden, nonmotorized boats.[c]	✓
Type of craft/vessel	Canoe, dinghy, wooden boat, boat with no deck	All households use wooden boat (not steel hull, fiberglass, or others).	✓	Almost all are wooden boats.[c]	✓
Type of gear	Not described	Most are gill net and hook and line, and virtually all are manual gears.		Out of 21,345 gears used nationally, gill nets comprise 34%; handlines 31%; and spears 27% (2009).[b] In a regional survey in five districts, 72% use handlines; 42% beach net; 34% fish net; and 31% gill net.[c]	
Fishing unit	Individuals, family, or community groups	All households conduct fishing as a family unit (almost all households have 1 to 2 members who fish).	✓	Except for the large-scale fishers in Atauro Island, nationally, most households conduct fishing as a family unit (2009);[b] 76% fish in small groups of 2–5 fishers and 23% fish alone.[c]	✓
Ownership	Craft/gear owner-operated	Vessels and gears are owner-operated.	✓	In a regional survey in five districts, 83% of boats are self-owned or family-owned, 13% is rented, and 4% is borrowed.[c]	✓
Type of commitment	Mostly part-time/occasional	More or less are evenly divided between those who fish everyday of the week and those who do not fish everyday.		In a regional survey in five districts, 72% fish every day, 54% spend less than 6 hours/trip, 22% spend 6–12 hours, 16% spend 12–24 hours, and 6% spend 2 or more days at sea.[c]	
Fishing grounds	On or adjacent to shore; inland or marine	For all, the fishing grounds are marine, adjacent to shore; and the duration of a trip is one-half or one day.	✓	Not described	

continued on next page

Table 31 *continued*

Characteristics	Subsistence Fisheries[a]	Survey (May to July 2012)		Regional or National[b]	
Disposal of catch	Primarily household consumption but some for local barter and sale	Primarily for sale and some for household consumption; 63% sell at fishing centers while 31% sell on the roadside, on the beach, at local market, and others.		A regional survey in five districts found that 27% of fishers sell their catch at a local market.[c]	✓
Utilization of catch	Fresh or traditionally processed for human consumption	Almost all are sold or consumed fresh.	✓	A regional survey in five districts showed that 60% of catch are sold as fresh product, and 36% process a small portion of catch before selling (traditional processing method); while outside of Dili and Atauro Island areas, the use of ice for preservation is very limited.[c]	✓
Knowledge and technology	Premium on skills and local knowledge; manual gear	Premium on skills and local knowledge; use of manual gear	✓	Premium on skills and local knowledge; use manual gear[b, c]	✓
Integration into economy	Informal, not integrated	Fully integrated in the economy		Nationally, mostly informal but integrated into the economy (2009)[b]	

Note: A check mark (✓) indicates that the characteristic is typical of subsistence fisheries.

Sources:

[a] FAO and WorldFish Center (2008).

[b] Kalis (2010).

[c] Regional description (for five districts) is based on AMSAT (2011).

Most households retained a portion of their catch for their own consumption, the rest were sold. The survey was conducted during the low season in fish harvesting when most of the catch or more than 50% of the catch was kept for household consumption. During the peak fishing season, however, the percentage could be as low as 2% or less.

The incomes of families involved in fishing are relatively high. Seaweed harvesting is a more stable source of income. However, the cost of living in Timor-Leste is quite high, and income from fisheries is spent for basic needs such as meat, vegetables, and rice—which most households do not produce. One small household with five members in Mane Mori earned $200–$400 every 2 or 3 weeks from selling harvested seaweed in Dili. The family lived in a very modest dwelling with dirt floor and thin walls, and their children were poorly clothed.

3. Conclusions

First, survey results and data from secondary sources indicate a significant dependence of Timor-Leste's households on fisheries, although not as high as expected. Fishing households have various livelihoods, including agriculture and husbandry. This situation is somewhat different from neighboring Indonesia, for example, where fishers do not generally engage in extensive farming practices, perhaps because of lack of land.

Second, disposal of catch is not mainly for domestic consumption, but also for sale in the community. Given its close proximity to Dili, fishers in Liquica are able to sell to the main markets, either directly or indirectly through wholesalers. In Dato and Ulmera, surveys indicate that many sales are made to local households for domestic consumption. While it is not clear what percentage of fishing is conducted at subsistence level, even the smallest fishing unit the opportunity to earn cash from the sale of fish in communities.

Third, the small-scale fishers of Timor-Leste do not have large debts to capital owners, such as seen in Indonesia. Fishers generally own their fishing assets, a house, and some land. While little can be concluded about the poverty level of fishing households (compared with households in other sectors), asset ownership and availability of capital allow for some production and cash earnings. However, the key question is whether earnings could enable them to undertake further investments in productive assets, education, and skills improvement; or are just enough to satisfy their day-to-day needs. (Full details of the survey and village census are available upon request from ADB).

D. Opportunities and Challenges in Valuing Subsistence Fisheries in the Philippines

1. Background

This section is based on the results of the workshop, Improving Fish Catch Statistics Collection in the Philippines with Focus on Subsistence Fisheries, which was held in February 2012 in the Philippines and organized jointly with the WorldFish Center. It involved the national agencies in charge of collecting and analyzing fisheries data , including the Bureau of Agricultural Statistics (BAS), Bureau of Fisheries and Aquatic Resources (BFAR), and the National Fisheries Research and Development Institute (NFRDI) (ADB 2012). The workshop aimed to assess the status of data collection in the subsistence fisheries sector and develop a suitable methodology for local government agencies.

The other objectives of the workshop were to increase awareness on the importance of the subsistence sector to production, food security, and household incomes; and to recommend policies that will institutionalize the collection of fisheries statistics, including subsistence fisheries. It further aimed for a better assessment of the contribution of subsistence fisheries to production, livelihood, and food security—data that are not being accurately recorded because of existing data collection protocols, divergent collection methods of national and local governments, and the spatial and temporal spread of fishing activities. By looking at the strengths and weaknesses of national fisheries collection and the initiatives of local governments to monitor fishing activities within their jurisdiction, some some methods could be converged and enhanced, including data sharing, streamlining, or harmonizing methods.

2. Data Collection by National Agencies

Two national agencies collect fisheries statistics—BAS and NFRDI. BAS consolidates all forms of agricultural statistics, including those for fisheries. To improve data collection in municipalities, BAS undertook a nationwide identification of municipal fisheries landing centers.[49] The list is updated regularly to reflect the importance of the landing center in terms of fish catch, which BAS ultimately uses in determining an "expansion" factor. There are also cases when management of a landing center changes hands or becomes inoperable. As of 2010, BAS monitored 8,779 municipal fish landing centers that provide estimates of municipal fish catch (BAS 2010). BAS hires contractual data collectors who are stationed at the landing sites to gather data from selected informants, such as fish traders, fishers, fishing boat operators, and fish brokers.

The NFRDI is the government's fisheries research agency. Data collected by the NFRDI are used for fish stock assessment. The National Stock Assessment Program (NSAP) aims to (i) determine the trend of seasonal distribution, relative abundance, size, and species composition of major marine resources in each fishing ground; (ii) provide estimates of population parameters of the major marine resources in each fishing ground; and (iii) complement BAS in generating fisheries statistics.

Both agencies indicated that subsistence fisheries are subsumed under municipal fisheries or are considered equivalent, and there are no efforts to collect data pertaining to this subsector at the national level.

3. Data Collection by Local Government Units

Representatives of local government units (LGUs) from eight municipalities participated in the workshop.[50] Based on information gleaned from the questionnaires distributed during the workshop, the minimum data collected by LGUs are the population and profile of both fishers and municipal fishing boats. LGUs also collect gear information and fish catch. Data collection is undertaken for (i) fisheries management, (ii) development of new regulations, (iii) submission to other offices (although not explicitly required), (iv) compliance, (v) grant and/or project proposal preparation, (vi) taxation, (vii) budgeting, and (viii) publication.

Data collection protocols among LGUs vary depending on their fishery activities, level of awareness on the importance of coastal resources, and capacity to embark on a monitoring scheme. Some municipalities (such as Lubang) reported no data collection in their municipalities prior to receiving technical assistance from Conservation International. Thus, there are no records on the number of fishers or fish catch; however, the LGU monitors fees paid by commercial fishers in its municipal waters. In Taytay, Palawan, which has a long history of live reef fish trade,

[49] Fish landing centers served as sampling units in production surveys for municipal fisheries.

[53] These municipalities included Bani, Pangasinan Province; Calauag, Quezon Province; Lubang, Occidental Mindoro; Masinloc, Zambales Province; Puerto Princesa City and Taytay Municipality in Palawan Province; Tiwi, Albay Province; and Zamboanga City, Zamboanga Province.

catch and trade data have been monitored since 2000. In addition, the LGU also keeps track of expenditures on the trust fund that was set up in 2007 to enforce marine protected area management.

In Zamboanga, there is interest in monitoring fish catches, especially on the impact of the closed season imposed by BFAR on the sardine fishery. Data related to activities of the processing sector (sardine bottling) are also monitored. The LGU of Bani, Pangasinan shared a novel way, but not entirely foolproof, in collecting data using *Bantay Dagat* or coast-watch patrols. *Bantay Dagat* volunteers are paid to collect information on fish catch, but the data collected were observed to be inaccurate. Calauag in Quezon Province reported that covering 46 coastal villages, some of which are not accessible by land, requires significant time and resources.

Data gathered are stored in logbooks, file folders, cabinets, ordinary computer programs, and in the Fisheries and Aquatic Resources Management Council database. To expand data collection to cover subsistence fisheries, the survey identified daily fish catch, fish species, volume traded, number of fishing boats/gears/fishers, and income as information that should be gathered. Potential data collectors include members of the Fisheries and Aquatic Resources Management Council, local councils, *Sangguniang Barangay* (village council), LGU, *Bantay Dagat*, NSAP, BAS, and BFAR.

All LGU workshop participants complied with fishing boat registrations and use of auxiliary invoices (Table 32). Most of them implemented fisher and gear registrations, but only two of the eight municipalities monitored fish prices. No systematic monitoring of fish catch for the municipal and subsistence sectors was done, except if the volume of fish traded is noted upon the issuance of auxiliary invoice.

Elements of Subsistence Fisheries and Estimation of Economic Contribution

A definition of subsistence fisheries was agreed upon during the workshop, and key elements and sources of data were determined based on existing knowledge and practices on the ground

Table 32 **Fisheries Monitoring** System of Local Government Units

Local Government Unit (Municipality, Province)	Fisher Registration	Fishing Boat Registration	Gear Registration	Auxiliary Invoice	Fish Price
Bani, Pangasinan	✓	✓	✓	✓	
Calauag, Quezon	✓	✓		✓	
Lubang, Occidental Mindoro	✓	✓	✓	✓	✓
Masinloc, Zambales	✓	✓	✓	✓	
Puerto Princesa City, Palawan	✓	✓	✓	✓	
Taytay, Palawan	✓	✓	✓	✓	
Tiwi, Albay	✓	✓	✓	✓	✓
Zamboanga City, Zamboanga		✓	✓	✓	

Source: ADB (2012).

Table 33 **Components of Subsistence Fisheries in the Philippines**

Parameter	Element of Subsistence Fisheries	Source of Data
Size and type of vessel	Fishing done is with or without boat; thus, it includes gleaning. If boat is used, it is 3 gross tons and below, usually nonmotorized; if motorized, size of engine is 10 horsepower and below.	Municipal fisheries registration
Fishing unit	Individual	Municipal fisheries registration
Ownership	Not more than one boat or no boat at all	Municipal fisheries registration
Time commitment	May be full-time or part-time	Municipal fisheries registration
Income level	Below food threshold	Department of Social Welfare and Development, through the Community-Based Monitoring System and National Household Targeting System; and National Statistical Coordination Board
Disposal	Combination of family consumption and/or returns on investment	Partially available from the National Stock Assessment Program
Fishing ground	Municipal waters	Municipal fisheries registration
Technology	Hooks and lines, barriers and traps, gillnets, spear guns	Municipal fisheries registration

Source: ADB (2012).

and what are known in the literature (Table 33). Based on the details in Table 33, the workshop agreed to define a "subsistence fisher" as

> …a municipal fisher who has no boat or owns one boat. He/she may either be engaged in gleaning or may use a boat that can be nonmotorized. The municipal fisher's boat weighs up to three gross tons and below and runs at a maximum of 10 HP and below. He/she mainly relies on fishing and his/[her] earnings fall below the food threshold. He/she uses the catch for a combination of purposes—including family consumption, barter, and reinvestment. He/she uses hook and line, gillnets, spear fishing, and barriers and traps… (ADB 2012).

Given these elements, subsistence fisheries comprise a subset of municipal fisheries, whose production does not enter the market either by choice (such as when fish is consumed at home, traded, or given away as gifts), or by location (when the location is not accessible to ready markets either by geography or absence of market infrastructure). To estimate the amount of fish retained by households for consumption, average catch per fisher per day was culled from the study of Muallil et al. (2012), which was based on a survey of 25 towns across the Philippines. An average of 4.8 kg/fisher/day was determined from the study, to which was applied a 10% retention rate for the amount of fish consumed in the household or given away. This translates to 0.5 kg/day per fisher or per household in cases where the fisher is also the head of the family. The volume of consumption translates to 195,000 t of fish or 16% of

Table 34 **Economic Implications of Subsistence Fisheries in the Philippines**

Parameter	Estimates of Subsistence Fisheries Contribution	Implications on Economic Variables
Volume of home consumption[a]	• 0.48 kg/per fisher/day • 658,000 kg/day for household consumption based on 1.3 million municipal fishers[b] • 195,000 t/year based on 300 fishing days per year	Fish consumed at household level amounts to at least 16% of municipal fisheries production from marine sector.
Value of home consumption	0.48 kg at $1.80/kg or $0.86 per day (P35.30)[c]	Value of fish consumed at household level is 22% of daily food poverty threshold of $3.95 or P162.00. Value of fish consumed at household level is 16% of minimum wage rate for agriculture sector workers outside Metro Manila, i.e., P225.00 or $5.50 per day.[c]

kg = kilogram, P = Philippine peso, t = ton.

[a] Estimated at 0.48 kg/fisher/day (Muallil et al. 2012); 10% retention is assumed.

[b] BFAR (2011). http://www.bfar.da.gov.ph/pages/AboutUs/maintabs/stat-fishcontri_2011.html

[c] At an exchange rate of $1= P41.

Source: Analysis by authors based on Muallil (2012) and BFAR (2011).

total production of the municipal marine sector on a yearly basis (Table 34). The value of fish consumed at home is estimated to be 22% of food thresholds and 16% of minimum wage rate for areas outside metropolitan Manila.

It is not difficult to appreciate why problems in data collection occur at both national and local levels. The nature of fisheries data is highly variable and disparate, and this occurs in virtually all coastal areas that are not regularly monitored. At the field level, the difficulties in obtaining data can be traced to the (i) lack of funding and personnel; (ii) lack or absence of a dedicated system for data collection, storage, and analysis; and (iii) location of villages, many of which are difficult to reach. The correct depiction of the contribution of subsistence fisheries to production, nutrition, household incomes, and food security is more apparent at the local government level but is also quite significant at the national level. This is the type of data required for poverty mapping, planning, and budgeting support for infrastructure and social services delivery; preparation of feasibility studies and project design for external funding; and appropriate valuation of incomes from natural resources.

E. Conclusions

In addition to the FAO's characterization of subsistence fisheries (underreported, economically undervalued, notoriously difficult to manage, and not fully considered in the development dialogue), this report contends that subsistence fisheries in CT6 countries are largely undefined and vaguely understood. In Solomon Islands, virtually all coastal fishers are subsistence fishers.

In the Philippines, subsistence fishers and municipal fishers are almost equivalent. In Timor-Leste, there are no subsistence fishers who fish for food only because the demand for fish is high, and the impetus for development is strong. Thus, the capture fisheries sector in that country is more small-scale than subsistence in nature.

This report also confirms the significant undervaluation of the subsistence fisheries in CT6 countries. Food goods derived from reefs across four study sites in Solomon Islands amount to subsistence and cash value ranging from SI$9,600 to SI$43,000 ($1,300–$5,900) per respondent per year, with fish being considered the most important reef good. Although this study provides quantitative data for only four rural villages, the subsistence and cash value of reef fish is estimated to range from SI$300 million to SI$1,000 million ($41–$145 million) per year, 4–13 times greater than previous estimates of the value of coastal subsistence fisheries. In the Philippines, the volume of fish consumed by fisher households is estimated at about 200,000 t or 16% of total municipal fish production from the marine fishery subsector.

The economic contribution of subsistence fisheries to local and national economies cannot be ignored further. However, due to the geographically dispersed location of most subsistence fishers and the wide divergence in fisheries effort and consumption, it may not be possible to apply the same rigor and systems that are currently used by national and local agencies for data collection. Rather, a method for estimating the proportion of subsistence catch, effort, and consumption at the local level, where information is more accessible, should be developed.

Data collection at the national and local levels shows some divergence in purpose and methods. National agencies collect fisheries and aquaculture statistics to determine the national profile of production trends for policy formulation. For subsistence fisheries, however, there is no demand for data by policy-making institutions. In addition to BFAR, which is the main user of data, other institutions may, in the future, influence BAS' data collection. Such agencies include those with poverty reduction and/or nutrition programs, which may find such information crucial.

Meanwhile, some synergies between local and national agencies can be nurtured. Opportunities to capture the contribution of subsistence fisheries exist, but the level of data collection will ultimately be guided by users of the information. In the case of the Philippines, local governments are the logical users of information on subsistence fisheries for general planning and budgeting, identifying required social services and infrastructure, poverty mapping, and livelihood support. A system for consolidating information at the local government level can feed into national policy when aggregated at the macro level.

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VI. Fisheries Value Retention in the Coral Triangle for Highly Traded Commodities

Annabelle C. Trinidad,[51] Joelle Albert,[52] Joel Palma,[53] Mavic Matillano,[54]
Delvene Boso,[55] Joe Pres Gaudiano,[56] and John Manul[57]

A. Introduction

All countries in the Coral Triangle, except Timor-Leste, are engaged in the global trade of fish and other aquatic products. The designation of a 200-mile exclusive economic zone has enhanced modes for quicker air transport. Meanwhile, improvement in technologies for the storage of fish has pushed seafood trade to higher levels. In 2011, the total trade in seafood products generated by CT6 countries totaled $3 billion for the export of tuna; live reef fish; aquarium and/or ornamental fish; and invertebrates, such as sea cucumbers, corals, and shells. From the aquaculture sector, seaweed and shrimps are the main exports of the CT6 countries.

The economic theory of international trade is that, in general, any country that engages in trade will be better off. However, it has become apparent that there are also losers, and that policy decisions can influence how the gains are distributed (Gudmundsson et al. 2006). Value chain analysis has become an important instrument to assess whether the global trade in aquatic products has benefited the producer countries and, more specifically, the sector that produces or harvests the products. Income distribution and impacts of globalization on poverty alleviation have been the focus of value chain analysis by Kaplinksy and Morris (2001). Value chains are useful analytical tools in fisheries because of the globalization of fisheries commodities, the sorting function or how heterogeneous products can be categorized into specialized markets, and a buffering function that allows for auctions and storage facilities for price stabilization (Trondsen 2007).

In the Coral Triangle, several value chain analyses have been performed. For example, Muldoon and Johnston (2007) applied a spreadsheet model that incorporates the risks and probability of attaining risk levels for various stages of the market chain, and explained why value distribution is seemingly unfavorable to the fisher. They showed that the fisher earns a maximum attribution value of 15%; the export subsector 25%–55%; the import subsector 5%–25%; and the retailer

[51] Footnotes 21, p. 43; 27, p. 63; and 32, p. 85.
[52] Footnote 34, p. 85.
[53] Coordinator, WWF-Philippines.
[54] Coordinator, Sustainable Live Reef Fish Trade Initiatives, WWF-Philippines..
[55] Footnote 36, p. 85.
[56] Coordinator, Sustainable Tuna Trade Initiatives, WWF-Philippines.
[57] Coordinator, WWF-Sablayan, Occidental Mindoro, WWF-Philippines.

and/or restaurateur 35%. In the Philippines, studies paint different pictures. Pomeroy et al. (2005) estimated the gross revenue distribution among the catchers, traders, and local governments in Coron–Busuanga area in Northern Palawan, and concluded that the fishers earned more than 80% of the value. Padilla et al. (2003), who estimated costs and revenues for live reef fishing, concluded that while profits were still being made, almost half of the fishers surveyed were starting to lose money. Elsewhere in CT6 countries, Brewer (2011) applied value chain analysis for coral reef fishes in five provinces of Solomon Islands. In addition, specific studies deal with particular segments of the chain, such as the relationship between incomes and imports of live reef fish in Hong Kong, China (Si 2005), regional and local-scale dynamics (Scales et al. 2007), elasticity estimates for various species of groupers (Petersen 2007), and wholesale and retail price integration (Petersen and Muldoon 2007).

Governance is also a key to assessing the performance of the value chain given that a producer-dominated value chain should be managed differently than that of a buyer-dominated value chain. In fisheries, value chain is more of buyer-dominated since the supply is not stable; prices are dictated mostly by the buyer; and the price premium is imposed by transporters and traders, rather than by producers or suppliers. When the chain is perfectly linked, the value changes are communicated efficiently and vice-versa.

This chapter reviews value chain studies done for countries in the Coral Triangle, which involved highly traded species, including tuna, corals, and live reef fish. The different nodes of the value chain, the participants, and their value-adding activities are described; and the value retained by fishers assessed. The results of a cost–benefit analysis of tuna and live reef fish in the Philippines, based on small surveys and catch monitoring of catches, are also discussed.

B. Tuna Value Chains in Mindoro Straits and Lagonoy Gulf, Philippines

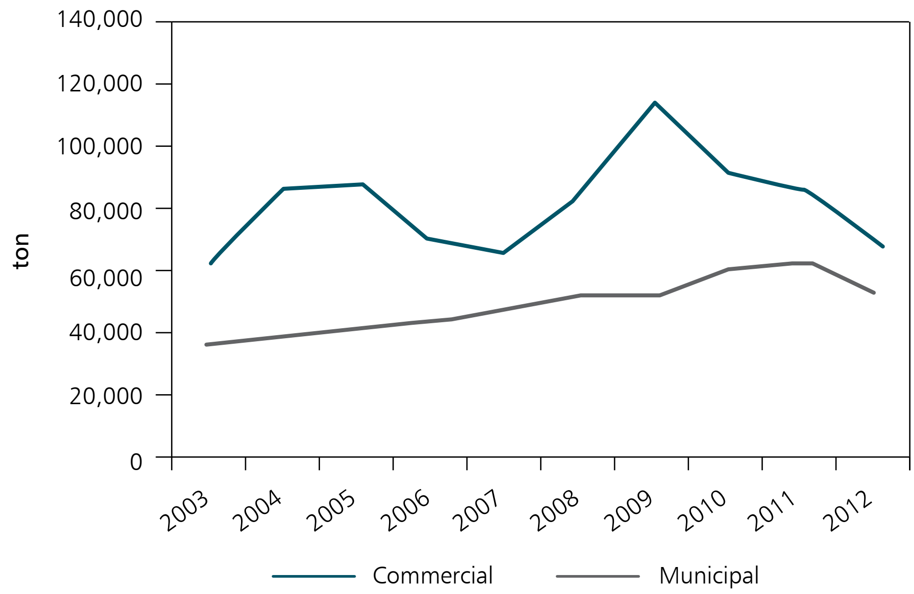
1. Overview of Tuna Fisheries in the Philippines

Tuna fishing has long been practiced among Filipino fishers, especially in the southern Philippine provinces of Cotabato, Davao, and Zamboanga. Early accounts of tuna and tuna-related fishing activities date back to the 1900s during the start of the American rule (1898–1946) in the country (Vera and Hipolito 2006). American tuna packing companies started operations in Zamboanga; and by the mid-1970s, the node of operations shifted to General Santos City, coinciding with the increased demand for sashimi-grade tuna from Japan. General Santos City then became the "tuna capital" of the Philippines. Industry sources report that more than 120,000 people in General Santos City are employed in the tuna industry.[58] At its peak, production of yellowfin tuna from General Santos accounted for 69% of total national production in 2009.

Exploited by both commercial and municipal fisheries sector, tuna—specifically yellowfin—accounted for 10% of the country's total fisheries production (including aquaculture), which was almost 5 million tons (t) in 2012. In 2008–2012, the average production of the commercial

[58] http://www.mindanao.com, 29 September 2009. http://www.mindanao.org/index.php?option=com_content&view=article&id=330:tuna-transport-crowds-gensan-fishport&Itemid=62

Figure 24 **Production of Yellowfin Tuna, Philippines**



Source : BAS (2012).

sector was 90,000 t; and municipal sector 56,000 t (Figure 24). The commercial fisheries production showed a drop after its peak of almost 120,000 t in 2009, followed by consistent annual declines—suggesting that tuna production from General Santos City was the main driver in this subsector.

Monitoring of catch per unit effort (CPUE) in General Santos City for yellowfin tuna by handline fishing fleet during 2006–2011 showed a decrease from 2007 until end of 2009, although catch rates were said to be higher than those in the late 1990s (BFAR, NFRDI, and WCPFC 2012). The decrease in catch rate during this period coincided with increases in days per trip, suggesting that a component of the fleet unsuccessfully traveled farther to obtain better catch rates. From 2009 onward, the same decline in CPUE was observed for the purse seine fleet operating in General Santos City, while catches of ring nets remained stable.

Tuna remains one of the Philippines' main fisheries exports, which also include seaweed and shrimps. In 2009–2011, tuna ranked first among 10 major exports, contributing an average of 100,000 t/year. Despite the drop in share from its peak in 2009, tuna still accounted for almost half of the volume of fisheries exports (BAS 2012). From 2009 to 2011, tuna yielded an average of P15 billion in export earnings on a yearly basis.

2. Tuna Handlining in Mindoro Straits and Lagonoy Gulf

Two tuna value chains were studied in the Philippines: the first was in the municipalities of Sablayan and Mamburao in Mindoro Occidental, and the second was in Lagonoy Gulf covering 15 municipalities in Albay and Camarines Sur provinces. In 2011, data were collected through household surveys and costs and returns surveys, supplemented by focus group discussions (FGDs).

Table 35 **Basic Production Parameters in Tuna Value Chain Analysis for Mindoro Occidental and Lagonoy Gulf**

Location	Total Production (t/year)	Catch (kg)/fisher/ trip	Number of Boats	Number of Fishers in Handline Fishing	Duration of Trip (hours)	Number of Trips/ Month	Number of Entrepreneurs
Lagonoy Gulf	18,000–24,000	35	8,250[a] or 1,872[b]	2,500	6–7	10 (lean season) 25 (peak season)	72 primary and 15 associate entrepreneurs
Mindoro Occidental	5,000	17–19	2,663 for the entire province	700 from Sablayan and Mamburao	3–5	3	6 in Sablayan; 12 in Mamburao

kg = kilogram, t = ton.

[a] Olano et al. (n.d.).

[b] Bradecina et al. (2011).

Sources: Costs and returns survey, focus group discussions, and on-site workshops.

Validation workshops were organized in Mindoro in September 2010 and in Lagonoy Gulf in February 2012. Both studies were supported by WWF-Philippines to enhance sustainable tuna fishing, improve transparency and traceability, and develop niche markets in Europe.[59] Both studies aimed to determine how much of the total value of tuna is retained by the fisher relative to the other participants in the supply and value chains, noting the critical role of the fisher in supporting sustainability initiatives. These tuna fisheries are based on handlining or hook-and-line fishing on small traditional boats; fishers use single hooks that catch tuna individually, causing less stress on the marine environment.

Some parameters derived from field data collection are shown in Table 35. Lagonoy Gulf is a larger tuna fishery, and CPUE is at least twice that in Mindoro Occidental. A census of handline boats yielded a total of 2,663 handliners, including fishers from other municipalities of Mindoro Occidental (Calintaan, Paluan, Rizal, and Santa Cruz), as well as the provinces of Batangas and Cavite. At least 43% of the handliners can be found in Sablayan and Mamburao. The wide range of estimated number of boats in Lagonoy Gulf is due to the variety of handline types being used for big tuna, small tuna, dolphin fish, and those using multiple handlines.

The duration of a fishing trip is 6–7 hours in Lagonoy Gulf and 3–5 days in Mindoro Occidental. Since Mindoro Occidental is closer to an international airport (Manila) and the fish could reach the exporter within 24 hours, tuna caught in Mindoro Occidental usually end up exported. In contrast, more than 70% of tuna landed in Lagonoy Gulf are sold locally.

[59] The studies on tuna are part of a 3-year conservation program being pursued by WWF-Philippines with support from the Danish International Development Agency under the Coral Triangle Network Initiative.

FGDs conducted in Sablayan and Mamburao in Mindoro Occidental reveal the following:

- The peak season for tuna is December to March when each boat would catch, on average, 200–300 kilograms (kg), or about 5–6 pieces of fish weighing 50 kg each.
- Production levels during peak and lean seasons vary depending on where fishing takes place in Lagonoy Gulf.
- Boats with four fishers operating for 2 days have a lean season production of 50 kg per fisher per trip, and a peak season production of 100 kg.[60]
- Lean season catches could be as low as one piece of tuna weighing 30–35 kg.

3. Characteristics of Supply and/or Value Chains for Tuna

The value chains in Mindoro Occidental and Lagonoy Gulf tuna fisheries are similar (Figure 25), although the former is geared toward the export market while more than 70% of tuna in Lagonoy Gulf is sold locally. The fastest route to the domestic consumer is through itinerant vendors (often wives of fishers), who sell the fish as soon as it is landed. Another route is through wholesalers and retailers operating stalls in markets. Wholesalers and retailers can have prior selling arrangements with fishers or they can bid for the catch. Brokers, referred to locally as *casas* or *consignacion,*[61] provide another node in the supply chain. They play roles in the financing of fishing operations, grading of fish, and transporting fish to the exporter. Grade A tunas are transported to the exporters' processing facilities. The "rejects" find their way to the domestic markets through wholesalers and retailers. Exporters are another source of "rejects" after processing and selecting choice parts (i.e., loins). The supply chain for tuna is rather short and is reflected in the time elapsed between landing and final consumption. Tuna from Mindoro Occidental can reach the exporter within 10 hours.

Value chain participants and roles. The fisher mainly provides labor inputs (before, during, and after the fishing activity), and expertise that depends on the time spent at sea and in preparing the fishing implements.[62] Oftentimes, participants in the value chain assume multiple roles, owing to the knowledge gained in fishery and sometimes also due to buildup of sufficient capital. In both Mindoro Occidental and Lagonoy Gulf, many *casas* reported starting out as small stall owners and/or retailers. Vertical integration occurs both ways, i.e., bottom–up and top–bottom. In the case of Mindoro Occidental, there is evidence of integration from top to bottom, with exporters making investments in fishing operations.

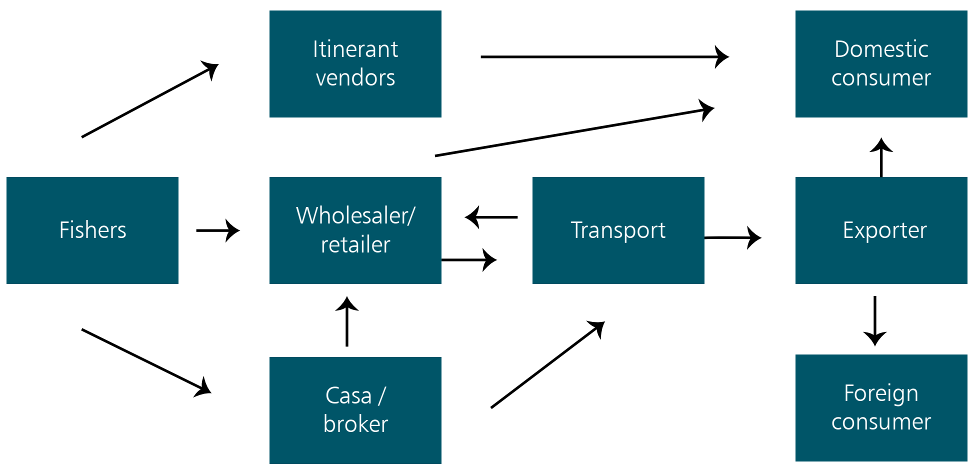
Generally, the supply chain starts with the fisher endorsing the catch to the (i) itinerant vendors, (ii) wholesalers and/or retailers, or (iii) *casas* or entrepreneurs. Tuna destined for the domestic market, either the proximate local markets or bigger markets in the metropolis, reaches the consumer through itinerant vendors, who sell fish in their communities or through retailers with market stalls.

[60] Data collected by WWF prior to the consultation yielded an annual average catch of 17.5 kg/fisher/trip.

[61] Both words have Spanish origins with *casa* meaning house, and *consignacion* meaning shipment or consignment, referring to the trading roles of the broker.

[62] A description of tuna handline operations is provided by Babaran (2010) in a related study commissioned by WWF as an initial attempt to characterize the fisheries of Mindoro Strait and estimate annual production.

Figure 25 **Generic Supply and Value Chains for the Tuna Fishery in Mindoro Strait and Lagonoy Gulf**



Source: Trinidad (2011a).

Tuna destined for the export market are inevitably coursed through the *casas* due to the grading function, since only Grade A tuna are qualified for export. Tuna graders double as agents or employees of exporters, and their main function is to assess the quality of tuna. As soon as the tuna is landed, graders poke the sides of the tuna with a long, hollow stick that provides a sliver of tuna sample; this is the basis for grading tuna (see photo). The grader is paid P5 per kg or roughly P250 for a 50 kg tuna. A better understanding of the parameters for grading tuna is needed.

The *casas* assemble, clean, put ice, and pack the fish in wooden crates before these are transported to the retail market or to the exporter. A more important role performed by the *casas* is serving as the *de facto* financier of handline fishing operations. In Sablayan, one *casa* narrated that she finances at least 50 fishing boats, with one of them incurring debts up to P100,000 or $2,500.

Often, *casas* fund handline operations but may also request financial assistance from exporters. It is also common for *casas* to nurture personal relationships with handline fishers and extend other forms of credit common in the rural milieu in the Philippines. For example, credit is extended for common household expenditures, educational assistance, and health assistance—especially during the lean season. This patronage system is sometimes touted as unfair or predatory as *casas* sometimes pay fishers lower than the usual prices. However, there are also instances when fishers would opt to sell their catch to other *casas,* despite a creditor having had a long-standing relationship with another.

Domestic transport cost is also shouldered by the exporter after having committed to purchasing the product; otherwise, the *casa* pays for the transport. In Mindoro Occidental, there is an established system of "share-a-ride," where the *casa* pays the transport costs according to the volume of fish shipped out. The transport cost is P14/kg to Manila, and each refrigerated van

John Manul, WWF-Philippines

Slivers of flesh indicate that this tuna has been graded.

can accommodate 2–3 t of fish. Within 10 hours after landing, the tuna reaches the export plant in Taguig City, which is about 10 minutes away from the international airport.

When the fish reaches the exporter, the fish is cleaned, loined, and iced again to maintain freshness. It is then vacuum-packed and placed in a giant ice chest where the temperature is maintained at 0°C. After 24 hours, or more commonly, 48 hours, the tuna is ready for its final packing, which may include applying cloth gauze to absorb extra blood, repacking, and stacking in styrofoam containers. Each box is labeled according to specifications provided by the buyer, which indicates where the fish was caught, its weight, and other conditions. After packing, the tuna is ready to be shipped; and within 20 minutes, the tuna is loaded onto an aircraft.

Price differentiation. Tuna pricing is based on quality and is an important consideration for the export sector. The quality of tuna is maintained by proper handling, including sufficient icing. Sometimes, boats are unable to bring enough ice due to space limitations, costs, or unavailability. In the Mindoro Occidental study, prices received by handliners are determined by *casas* who base their offers on prices offered by the exporter. Ultimately, the price offered is based on the grades assigned to the tuna. *Casas* may just offer a standard price even prior to grading, which is often an average price for Grade A and Grade C. This reflects a risk-taking attitude among *casas*. At the time of the study, a "straight pricing without grading" was P120/kg while the price for Grade A tuna was P160/kg. The *casa* can also vary the prices offered to fishers, i.e., a lower price can be offered to some fishers with debts.

In the Lagonoy Gulf study, prices received by fishers ranged P90–P100 per kg, depending on the lean and peak seasons. The range is quite narrow for those targeting the domestic market. Fishers targeting the export market may avail of a wider price range because of product differentiation introduced by the grading process. Grade A tuna can be bought at a range of P140–P150 per kg. The price markup of *casas* and retailers is narrow at P10–P20 per kg. The range of buying prices for consumers reflects the changing patterns of demand. In the Lagonoy Gulf fishery, the buying price of tuna is also influenced by the production of other fishes, especially those caught by ring nets.

4. Fisher's Share of Value

To determine the value retention at the fisher's level, the price at which the end consumer purchases tuna is used as the final value. Since the objective is to assess—through supply and value chain analysis—whether international trade is beneficial to tuna fishers, the price or value of interest is the consumer price at the exporting country. The study supported by the WWF-Philippines ascertained how sustainability initiatives at the fisher's level (low-impact gear, traceability, and improvement of quality) coincided with improved value retention. A value of $17/kg was used and distributed across the value chain participants starting with the exporter and ending with the fisher (Table 36). This figure was obtained from an interview with a Manila-based exporter for tuna sourced from Mindoro Occidental; the same pricing scheme was utilized for Lagonoy Gulf. The price is the contract price of the wholesalers and/or supermarket chain in Europe, and not the price to consumers.

The value-adding contribution of the handline fisher was estimated by costing the inputs to the production process—labor, technological, and physical inputs (boat, engine, bait, gasoline, and ice). Other operational costs included repairs, especially of boats, engines, generators, and others. The Mindoro Occidental survey also sought information on fixed costs such as taxes, licenses, and insurance; and marketing costs such as auxiliary invoices, landing fees, and commissions. But the survey yielded none or very scanty information. Ice is also an important cost item. Ice requirements depend on the projected travel time or how much ice is available. Some fishers tend to give less importance to ice, thus diminishing the quality of tuna.

The average cost to produce a kilogram of tuna was estimated at $1.23 in Mindoro Occidental and $1.59 in Lagonoy Gulf (Table 36). Higher average production required more ice inputs, thus, the higher cost for Lagonoy Gulf handliners. Since there was no "buying price" for tuna,

Table 36 **Comparison of Value-Adding Contributions and Margins in the Supply/Value Chain for Tuna, Mindoro Occidental and Lagonoy Gulf**

($/kg)

Segment of Value Chain	Price	Value Adding	Value Adding Plus Buying Price	Selling Price	Margins
Lagonoy Gulf					
Handliners	0.00	1.59	1.59	3.26	1.67
Casa	3.26	0.20	3.46	4.19	0.73
Exporter	4.19	5.53	9.71	16.98	7.27
Mindoro Occidental					
Handliners	0.00	1.23	1.23	1.86	0.63
Casa	1.86	0.51	2.37	2.79	0.42
Exporter	2.79	5.46	8.25	16.98	8.73

Note: The reports submitted to WWF-Philippines used peso values. All numbers were converted at the exchange rate of $1 = P43, the average rate during the study.

Source: Trinidad (2011a).

the difference between the selling price and the value-adding amount constituted the profit or the margin. The selling price differed, with a higher margin for Lagonoy Gulf and lower for Mindoro Occidental. It should be recalled that the export market is still nascent in Lagonoy Gulf, and fishers earn substantial profits even when selling in domestic markets. The role of *casas* is, therefore, limited to exporting; thus, there is lower value addition for *casas* in Lagonoy Gulf.

Exporting tuna requires a large amount of value addition at the exporter side, with a minimum of $5/kg as opposed to the handliner whose value adding contribution is $1.20/kg, at the minimum. This is because of the huge material and management inputs of the exporter, especially as the node of traceability requirements. The *casa* contributes the least to value addition. Functioning more as a financier and consolidator of catch, the *casa* spends very little time with the fish; and the processes undertaken by the *casa* are rather minimal for grading, which is done rather quickly.

The ultimate value of the consumption of tuna by foreign consumers is $17/kg, where 43% constitutes value addition and 57% for the profit margin. Value addition is equivalent to the costs spent to catch, grade, clean, process, transport, and distribute tuna; and it includes the cost of labor and capital. The profit margin is earned by subtracting the value adding amounts and the buying price from the selling price.

Value distribution is similar for Lagonoy Gulf and Mindoro Occidental. For value addition, exporters account for more than 75% of the value, while fishers contribute 17%–21%. *Casa* operators contribute less than 5% of the value; it is less in Lagonoy Gulf than in Mindoro Occidental, owing to the number of *casa* operators (and hence, greater competition) and the less-developed export sector in Lagonoy Gulf. In Mindoro Occidental, the bulk of the margin is cornered by the exporter, and the amount is greater than in Lagonoy Gulf.

5. Conclusions

The preceding analysis suggests that fishers can improve their margins if value addition is enhanced, and the selling price of tuna is improved as Grade A generally fetches higher prices. Aspiring for Grade A requires better icing and handling while getting higher prices implies other factors, including greater demand (which is seasonal), effective price transmission, greater competition among buyers, and less financial entanglements between the buyer and the seller. In the Mindoro Occidental study, margins increased by at least 10% even if average catch rates were maintained, when the grading of tuna is improved from Grade C to Grade A. The results also imply that fishers can benefit from increased value of tuna without having to increase catch.

Under the framework espoused by WWF, price premiums are assured if the fisher is involved in traceability requirements by ensuring the registration of boat, gear, and person. Likewise, compliance with sustainability standards in the use of hooks and fish aggregating devices can be rewarded through better prices. At present, the onus of traceability and sustainability lies with the exporter; and, hence, their margins are greater.

It is also relevant to determine if the tuna handliner is financially better off if he is engaged in another form of employment that is reflected in terms of average wage rates. Looking at the net returns arising from three types of grading of tuna and the prevailing average catch rates for the two municipalities, the net return for an ordinary crew member is greater than the average wage rate for both municipalities if the tuna is given a Grade A.[63] In all cases, net returns for Mamburao were always higher than the average wage rate, making tuna handlining a desirable economic activity.

To determine the value retained by tuna handlining, the final price paid by the consumer needs to be considered. Based on information from www.mysupermarket.co.uk, a value of $43.94 was used for 1 kg of tuna loin.[64] Given this price structure, the value retained by the producer, including all nodes of the supply chain based in the Philippines, is roughly 40% of the final value. Whether this ratio is fair depends on whether the remaining 60% comprises value adding cost or purely margins. A more detailed analysis of the value-adding costs of wholesalers and retailers in Europe is required. For now, this report concludes that tuna handlining is an economically beneficial activity based on studies conducted in two sites in the Philippines, especially if costs can be lowered and buying prices can be improved.

C. Live Reef Fish Value Chains from Taytay, Palawan

1. Overview of the Live Reef Fish Trade

The volume of trade in live reef fish (LRF) is 30,000 t/year—concentrated in Hong Kong, China and southern People's Republic of China—from 20 economies in Southeast Asia and the Pacific (Sadovy et al. 2003; Muldoon and Johnston 2007). While tuna comprises less than one-twentieth of the global fish trade, LRF fetches a handsome return of $400 million–$1 billion (McGilvray and Chan2001). Hong Kong, China—the major importer—imports about 11,000 t of LRF consisting of high-value species, of which 3,000 t are transported by sea vessels. Some 50%–70% are sourced from the wild (Pomeroy et al. 2005), another 20%–40% from aquaculture grow-out of wild seed, and the remaining volume through full cycle culture.[65]

Trade in LRF has evolved over the years. In the 1970s, many of the live groupers in Hong Kong, China were supplied from the South China Sea and the Philippines. By the 1980s, live groupers were increasingly sourced from Indonesia and Malaysia; and by the 1990s, it had extended to Fiji, the Maldives, Papua New Guinea, Solomon Islands, and other Pacific island countries. By 2009, the sourcing of live reef food fish by Hong Kong, China reached more than 50 economies, according to WWF (To 2011). Scales et al. (2007) measured the expansion away from Hong Kong, China at the rate of 100 kilometers (km)/year during the 1970s, increasing to 400 km/year in the 1990s.

In Hong Kong, China, the high-value species include humpback grouper, humphead wrasse, giant grouper, leopard coral grouper, and spotted coral grouper. Of particular interest to this

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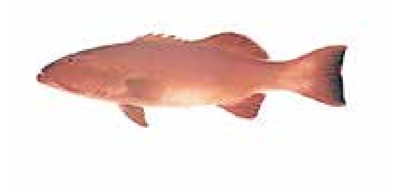
63 The share of each unit of labor is based on an arrangement, which is called *"tersyiahan,"* a derivative of the term "third" in local parlance. After deducting all costs, the net revenue is divided into three portions: one-third to the captain; and the remaining two-thirds divided into three, which is again divided among the captain and the remaining crew members, which, in the analysis is assumed to be three persons.

64 The prices are current and may differ from prices at the time of the studies.

65 At the time of writing, this is true only in Taipei,China.



Lory Tan, WWF-Philippines

The leopard coral grouper, *Plectropomus leopardus,* locally known as "suno" in Palawan.

Table 37 **Volume and Value of Exports of Live Reef Fish for Food, Palawan, 2003–2007**

Year	Reported Volume of LRF Shipped out of Palawan (t)	Approximate Gross Value based on Landed Price of P1,800/kg in Manila (P million)
2003	305.19	549.34
2004	517.92	932.26
2005	531.82	957.26
2006	769.26	1,022.00
2007	669.08	1,200.00

kg = kilogram, LRF = live reef fish, P = Philippine peso, t = ton.
Source: Pontillas et al. (2007).

study is the leopard grouper (*Plectropomus* spp.), which is the preferred species of hook-and-line fishers (see photo). Shipments of the leopard coral grouper are monitored by the Palawan Council for Sustainable Development (PCSD) (Table 37). Shipments of LRF grew from 300 t in 2003 to almost 700 t in 2007, which appeared consistent with the import figures of Hong Kong, China amounting to about 1,000 t/year for leopard coral grouper from the Philippines. The LRF trade is worth at least P1 billion per year, which includes other species of grouper enumerated previously.

Palawan supplies at least half of the Philippines' production destined for the LRF market. Of its 23 municipalities, 16 are documented as LRF sources. Five of these are both harvest areas and transfer points—Balabac, Coron, Magsaysay, San Vicente, and Taytay. The only international airport in Palawan is in Puerto Princesa City, but there is an existing city ordinance that bans the collection and shipment of certain LRF species, which effectively prevents transshipment. The other provinces engaged in LRF trade are Eastern Samar, Surigao del Norte, and Tawi-Tawi.

Live reef fishery in the Philippines has evolved and adapted to the trends in the global trade. The main factors that contributed to its evolution are the (i) tendency for groupers (especially the high-value species) to be overfished due to their stationary behavior, long lifespan, and spawning patterns; (ii) increasing demand and high prices of LRF due to increasing incomes in importing economies such as Hong Kong, China; (iii) stringent price structure based on the size of fish; and (iv) more efficient transport of LRF, fueling greater demand.

Evidence of overfishing may be gleaned from the Calamianes Islands case, which has a long history of LRF trade. Decreasing catches, export volume, and the average size of *P. leopardus* are indicators of overfishing (Padilla et al. 2003) as are the increasingly long distances traveled by fishers and their increasingly long hours spent at sea. The fishers and cagers involved in this study attested that live groupers caught are usually small in size (called "tropical"), weighing about 100–200 grams (g), validating the observations of Padilla et al. (2003) and Pomeroy et al. (2005) on the boom-and-bust cycle experienced in the Calamianes Islands. The PCSD has concluded that (i) the Palawan live reef fishery is unsustainable; (ii) mean sustainable yield is estimated at about 186 t/year, which is far below current production levels; and (iii) urgent measures need to be put in place (Pontillas et al. 2007).

At its peak in 1997, the annual trade volume in LRF was about 50,000 t at the retail end. By 2002, the volume was down to about 20,000 t, mainly due to overfishing in traditional source areas. The search for LRF has moved beyond the traditional grounds to islands in the Pacific. Scales et al. (2007) tracked 19 source countries for LRF and observed that 10 of them went into boom-and-bust LRF cycles.

Some of the ways in which the industry has evolved include the shift to cage culture of juveniles, the vertical integration of the supply chain, and the resulting ambiguity and/or mingling of roles of the participants in the supply chain. The fattening of juveniles in cages may seem to be an effective adaptation mechanism, but it is also driving fishery to overexploitation. Fishers would rather catch juveniles and fatten these in cages than risk catching larger fish (bigger than 1 kg/piece or the size of a plate), for which prices drastically drop. Some 20 years ago, when the LRF trade was just starting in Palawan, fishers would simply endorse their catches to shippers; now, shippers have started establishing buying stations and trade has evolved into an integrated capture and ranching activity.

The roles of supply chain participants have also become intertwined and melded. This vertical integration was the result of efforts to minimize risks and costs in the face of declining supply. Fishers have become fisher-cagers while traders have become actively engaged in fishing and caging. At the same time, traders also serve as agents of wholesalers based in Hong Kong, China. The option to transport fish by air, even in smaller quantities, has also encouraged restaurants to buy directly from wholesalers, rather than from retailers; thus, blurring the roles further in the supply and/or value chain.

2. Description of the Study on Live Reef Fish Trade

Addressing the issue of sustainability in the live reef fish trade (LRFT) involves a broad spectrum of work that spans basic and applied research on the biology of LRF species, market transformation, governance, and advocacy. This study on LRFT supports developing and implementing policies on ecosystem approach to management of fisheries (EAFM), which is Goal 2 of the CTI regional plan of action. One of the goals of the EAFM component is that by 2013, there will be a 20 percent increase in cash income of local government and fishers from live reef fish trade. The increase will be attained by harvesting fish from sustainable sources and the protection of at least 3,500 hectares of critical habitats of economically important reef fishes.

Taytay and Quezon municipalities in Palawan Province are the foci of the study because of their strategic role in LRFT at present. Taytay has the most number of producers (64%) and cagers (70%) of the total number in Palawan. Quezon's LRF industry is a developing one; thus, it could map out LRF strategies using the experiences of Taytay and that of Coron, which was an important player in the past. This report also recognizes the efforts of Taytay to develop the first-ever sustainability plan for managing the LRF over a 10-year period (2010–2020). This plan includes a robust catch-and-effort monitoring system, the designation and stricter enforcement of marine protected areas that cover spawning aggregations now totaling 100 hectares (ha) under the management plan, and imposition of minimum size limits for groupers entering the trade.

WWF conducted several research studies covering LRFT that started with a status report (Cantos et al. n.d.); catch-and-effort monitoring (Palla and Gonzales 2010); and an income survey report (Cola et al. 2009), which contributed to the development of the Sustainability Plan for the Municipality of Taytay 2010–2020.

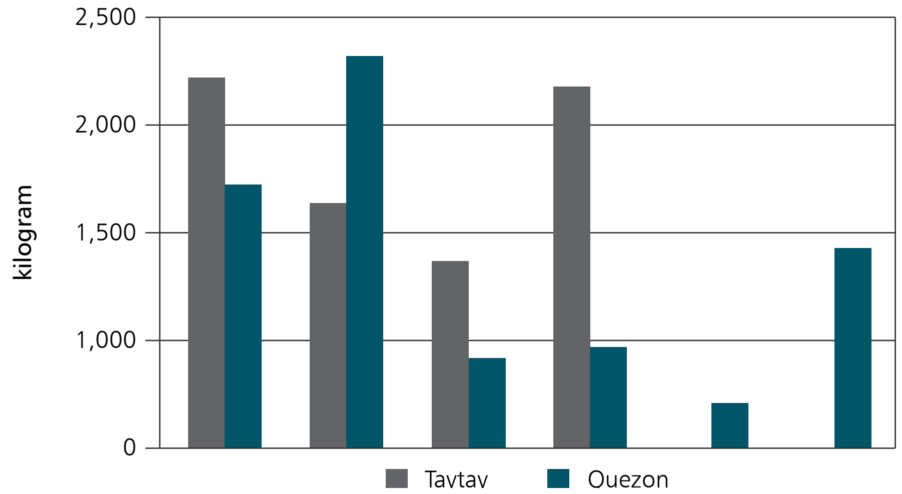
For this supply and value chain study, a mini survey was conducted in both Taytay and Quezon, comprising of hook-and-line fishers and cagers who were also previously surveyed for the income profiling (Cola et al.2009). Complementary to the income survey implemented by WWF, data was verified by WWF research assistants in February 2011, with a few key informants who collected specific cost information. In Taytay, the villages of Biton, Pularaquen, and Talacanen were included as part of a mini key informant interview. Respondents were asked about costs and revenues of hook-and-line and caging operations. Seven hook-and-line fishers were surveyed in Taytay and five in Quezon; six cagers were surveyed in Taytay and five in Quezon; and three exporters were also surveyed in Quezon. Price data for leopard groupers and substitute species, and import data from Hong Kong, China, were provided by Allen To of WWF-Hong Kong, China.

3. Overview of Live Reef Fish Fishing in Taytay and Quezon

Based on the catch-and-effort monitoring conducted by the Western Philippines University from November 2010 to February 2011, catches of handliners operating in Taytay and Quezon in Palawan were compared (Palla n.d., Palla and Gonzales 2010). Fish landing surveys in Taytay were conducted at major landing sites in Biton, Paly and Casian Islands, and Poblacion, while monitoring for Quezon focused on Alfonso XIII. Average monthly catch for the period was 1,015 kg for Quezon and 1,600 kg for Taytay (Figure 26). Fishing effort—measured by the number of fishers multiplied by hours—was consistently higher for Taytay for all months, with the highest in November 2010. Average monthly fishing effort for Quezon was 2,800 fisher-hours, while that in Taytay was 5,400 fisher-hours. The number of fishers in Taytay peaked in October 2010 (763 fishers), then started to drop from November 2010 onward, and increased again to about 600 fishers in February 2011. The spike in production and fishing efforts toward November through February coincided with the celebration of Christmas and Chinese New Year. Those interviewed for this study did not indicate that these were the same peak months. The earlier study by Padilla et al. (2003) also noted that fishers did not have a clear notion of peaks and just caught wherever and whenever fish was available.

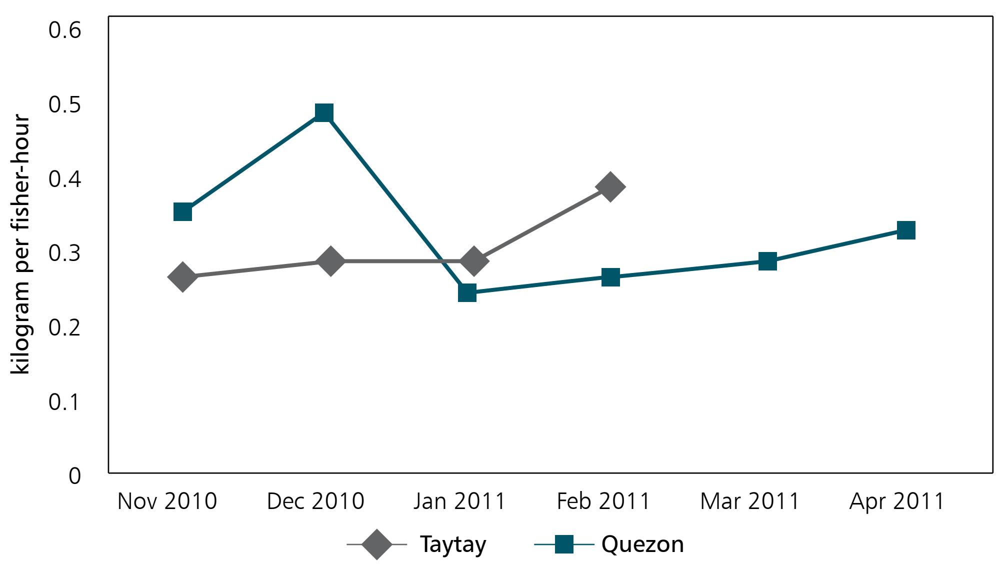
Overall, the catch per unit effort (CPUE) in both municipalities was almost similarly valued—0.30 kg/fisher-hour in Taytay and 0.33 kg/fisher-hour in Quezon (Figure 27). The earlier work of Cantos et al. (n.d.) estimated CPUE for leopard coral grouper at 199 g/fisher-hour, less than the figure indicated in this study. Groupers comprised an average of 28% of the catch in Taytay and 3%

Figure 26 Comparison of Catches of Simple Handlines in Taytay and Quezon, Palawan (November 2010–February 2011)



Source: Trinidad (2011b).

Figure 27 **Comparison of Catch Per Unit Effort, Simple Handlines, Palawan**



Source: Trinidad (2011b).

in Quezon, indicating the relatively "young" LRF fishery in Quezon. Other species constituted more than 90% of the handline catches in Quezon and only 62% in Taytay while invertebrates contributed roughly 10% in both towns. Based on monitoring conducted by Palla and Gonzales (2010), good-sized groupers comprised 19% of live fish in Taytay and 30% in Quezon. Undersized groupers comprised 60% of the catch in Taytay but only 7% in Quezon. Oversized fish seemed to be more abundant in Quezon, contributing more than 60% of the catch.

4. Live Reef Fish Supply and Value Chain in Taytay, Palawan

Taytay has the highest number of LRF fishers (more than 2,500 fishers) in Palawan, almost half of whom use hooks-and-lines, also referred to as handlines (Table 38). Based on the Sustainability Plan for the Municipality of Taytay 2010–2020, more than 300 fishers are still engaged in compressor fishing, which is usually associated with cyanide. Table 38 shows the number of cagers, traders, and accreditations by the PCSD. Their actual numbers, when compared with the official numbers from PCSD, show a huge discrepancy.

Caging is more prominent in Taytay compared with Quezon town. In Taytay, there is almost a similar number of fishers and cagers, implying that the roles of fishers and cagers have become ambiguous or that the process is now more integrated. The PCSD refers to both fishers and cagers as "producers." Traders are usually agents of Manila-based exporters. Cagers in Taytay and Quezon habitually engage in business with Young Marine Products and GB Company. These exporters have fielded traders in various parts of Taytay and Quezon, even in the island

Table 38 Estimated Number of Supply Chain Participants in Taytay, Palawan

Supply Chain Participants	Estimated Numbers	Location	Source
Fishers	2,500 fishers in Taytay, but 886 are live reef fish (LRF) fishers using hooks-and-lines; >300 LRF fishers in Taytay using compressors; 105 LRF fishers in Quezon	Palawan	Cantos et al. (n.d.), Cola et al. (2009); M. Matillano (personal communication, May 2011)
Cagers	1,198 cagers with 2,405 cages in Taytay 9 cages in Quezon 62 accredited cages in entire Palawan 19 accredited cages in Taytay 4 accredited cages in Quezon	Palawan	Cantos et al. (n.d), M. Matillano (personal communication, May 2011), Palawan Council for Sustainable Development (PCSD)
Assemblers/ traders	89 accredited traders in entire Palawan 14 accredited traders in Taytay 7 accredited traders in Quezon No record of actual numbers	Palawan	PCSD
Exporters	20	Manila	California Environmental Associates
Importers	56	Hong Kong, China	Allen To quoting data provided by the Hong Kong Chamber of Seafood Merchants Limited (personal communication, May 2011)
Wholesalers	90 (including fresh and live fish)	Hong Kong, China	Fish Marketing Organization of Hong Kong, China
Retailers	1,250 seafood restaurants; 800 seafood restaurants selling LRF	Hong Kong, China	Openrice.com; McGilvray and Chan (2002)
Consumers	7.1 million	Hong Kong, China and People's Republic of China	www.indexmundi.com

Sources: See last column and also in Trinidad (2011b).

villages, to be close to the source. Exporters are also affiliated with importers and wholesalers based in Hong Kong, China—an evidence of vertical integration in the industry.

There are some 56 LRF importers in Hong Kong, China based on information provided by Allen To (personal communication, May 2011), and gleaned from the records of the Hong Kong Chamber of Seafood Merchants Limited, the live fish importers' trade association. As shown in Table 38, there may be 800–1,250 seafood restaurants in Hong Kong, China that sell LRF.

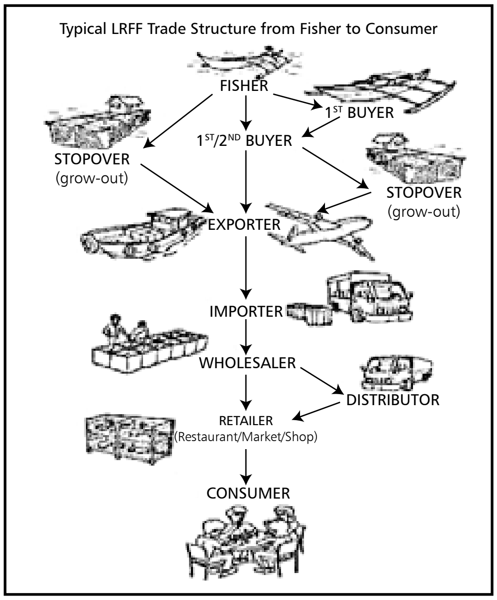
Value-adding activities per supply node. A simplified representation of the supply chain is provided in Figure 28, with the nodes representing those identified by Muldoon, Cola, and Pet-Soede (2009). The description of the role of importers, wholesalers, and retailers in Hong Kong, China is discussed based on Chan (2000); and is also contained in the WWF consultancy report (Trinidad 2012).

Fishers. The fisher provides labor and, optionally, a set of gears for hook-and-line fishing, unless these are provided by the boat owner. Sometimes, the fisher owns the boat, and may or may not finance the fishing operations, which include the cost of fuel, food, cigarettes, and bait. Aside from hook-and-line, spear gun and cyanide are also used. Barbless hooks-and-lines are normally used to minimize damage to the fish, but barbed hooks are still used. Fishers in Quezon take longer trips and travel farther than those in Taytay. On average, 2–4 fishers, but as many as 12 fishers, join the trip; and when this happens, they bring their own bait. Quezon fishers use hooks-and-lines with accessories called "*cristalet*" shell (lure) and chicken feathers. An average fishing trip lasts for 5 days (total travel time and actual fishing). In good coral reef areas, fishing time takes an average of only 1 hour; in areas where coral reef cover is not as good, it could take 4–8 hours.

Cagers. Cages in Palawan can be submerged, hanging, stationary, or floating. Hanging or floating cages are preferred because these allow the cagers to move them when they notice that the sands beneath become discolored. Cagers prefer locating near coral reef areas or in areas where the sand beneath is white, believing that these lead to better-colored fish (more brilliant red in color). The cager contributes labor (mainly acclimatization, feeding fish, guarding, monitoring, and sorting) over a period of 3–4 months; and also capital, which is used in constructing cages and for operational expenses like feeding the fish. Cagers described a process akin to acclimatization, which occurs before the actual grow-out stage. They set up makeshift cages adjacent to the boat or inside the boat so as not to disturb the fish. After the acclimatization, grow-out commences. The cager may utilize its own labor or may opt to pay for caretakers, especially to ensure that no theft occurs. At the end of the grow-out period, the cager arranges for transport to the holding facility of the buyer or trader.

Traders or buying station. Traders maintain aquariums in their houses, which are rented by the exporter on a monthly basis. Their main role in the supply chain is to assemble fish in quantities suitable for transport and to prepare the fish for transport (either by air or by ship). After fish is delivered, these are acclimatized and moved into aquariums until such time that the required volume is attained. The process of packing the fish, aerating the plastic bags, placing them in polystyrene boxes, and into cardboard boxes completes the preparation. This very sensitive process requires a high level of skills and precision, which has been described in great detail by Chan (2000).

Figure 28 **Participants and Roles in the Live Reef Fish Supply and Value Chains**



Fisher – catches fish

Trader – converts of fish to cash

Stopover (cager) – feeds, rears until good size

Assembler or trader – agents of exporters; prepares fish for transport

Exporter – prepares fish for export

Importer – receives of fish in Hong Kong, China, with distribution channel

Wholesaler – wholesaling

Retailer – markets to restaurants

Source: Muldoon, Cola, and Pet-Soede (2009).

Traders or buyers in Taytay and Quezon are agents of Manila-based exporters, who also have established trade links with an importer based in Hong Kong, China. An experienced operator knows how much time the packing team requires to pack one box. The team will start packing with just enough time to finish their task and move the container to the airport in time for the flight. Traders are said to derive commissions, but they claim that their earnings come from "rentals" of aquariums. For value chain analysis, the traders' earnings are charged against the exporters as costs since they do not earn from a price differential but from mere rentals.

Exporters. Exporters contribute to the supply and value chains in terms of capital, operating expenses, and own labor. A large amount of investment is needed to purchase fish from the fishers and/or cagers while operational expenses are incurred for transport, holding, marketing, and documentation. Once fish reaches Manila, they are revived and repacked. Information collected from this study identified at least 20 exporters based in Manila. The earlier work of Padilla et al. (2003) described the operations of four major exporters (Fordelon, Great Ocean, Kenneth Aquamarine, and Sea Dragon). Informants for this study also mentioned Young Marine Products and GB Company as their main contacts. Consistent with the observations of Padilla et al. (2003), the exporters have tie-ups with local buyers and/or trading stations or the latter act as their agents. Exporters secure the export commodity clearance, export declaration, and export permit in addition to paying insurance fees (security service charge and airwaybill).

Pricing characteristics. From October 2008 to May 2011, wholesale prices of *P. leopardus* were above HK$500 per kg. From 15–21 July 2011, it was HK$561 per kg while retailers sold at HK$498–HK$906 per kg ($64–$116 per kg). Peak pricing is noted during celebrations such as Chinese New Year, Christmas, and Mother's Day; and during wedding banquets and corporate events. Bright red-colored live reef fish are preferred due to their auspiciousness, and association with health, general well-being, and virility (Erdman and Pet-Soede 1996).

Pricing has several dimensions. One is how price is transmitted down the value chain. Another pertains to price differences associated with the different sizes of fish. Factors such as species, color, and marketing arrangements influence price. However, for purposes of a cost and return analysis, size is the defining factor; and it allows some level of simplification.

Three price levels were analyzed to determine price differentials: (i) retail (HK$); (ii) wholesale (HK$); and (iii) fisher and/or cager, which can be said as the beach price. From information generated through structured interviews and FGDs, prices at fisher and/or cager are wide-ranging (Table 39). In Quezon, prices start at P1,800/kg for a good-sized grouper; but in Taytay, the starting price is P2,000/kg. Data collected by WWF indicate that prices for red grouper can go as high as P2,800/kg during the peak months of December and January. Variability in pricing can be attributed to marketing arrangements (between the exporter and local buyer), forward price information, volume handled, and marketing and transport costs. In the last case, increasing the volume would make the cost of transport cheaper, thereby increasing margins.

Using P1,800 as the base price, the differential between the price received by the fisher and/or cager and the wholesaler based in Hong Kong, China is almost 100%, while there is an observed overlap between the price range of the wholesaler and retailer. Comparing the lower range difference yields a 66% variance, while the upper range difference is only 17%. The mid-range differential averages 48% between the fisher and/or cager and wholesaler, and 30% between the wholesaler and retailer. The markup observed in this study is less than that observed by Sadovy et al. (2003), who pointed out a 100%–150% markup between wholesale and retail, but is consistent with the observation of Chan (2000) in which the markup between wholesale and retail ranges from 24% to 35%.

At the fisher and/or cager level, pricing is associated with a preferred size. Table 40 indicates that a good-sized (i.e., the size of a plate) fish weighing an average of 0.5–1.0 kg is priced at least

Table 39 **Pricing of Live Reef Fish across the Supply and Value Chains**

Selected Value Chain Participant	Price Type	Price Range (per kg, unless stated otherwise)
Fisher and/or cager	Good-sized	P1,800–P3,000
	Tropical	P0.50–P0.75 per piece
	Oversized	P300
	Other species (brown grouper)	P1,600
Wholesaler	Wholesale price (Hong Kong, China dollar [HK$])[a]	HK$300–HK$775; $39–$100; P1,656–P4,278
Retailer	Retail price at Hong Kong, China restaurants	HK$498–HK$907; $64–$117; P2,750–P5,000

kg = kilogram, P = Philippine peso.

[a] As of January 2011.

Note: Exchange rates used are $1= P44 and HK$7.8.

Sources: Prices for fishers and/or cagers based on Cantos (n.d.); and wholesale and retail prices based on Fish Marketing Organization of Hong Kong, China.

Table 40 **Comparison of Grouper Prices in Palawan, Philippines, 2009**

Size Category	Average Price (P/kg)	Peak Price (P/kg)
Undersized (0.3–0.5 kg)	300–500	300–500
Good-sized (0.5–1.0 kg)	1,800–3,000	2,200–4,000
Oversized (>1 kg)	300–500	400–600

kg= kilogram, P = Philippine peso.
Source: Cantos et al. (n.d.).

5 times more than an undersized or oversized fish. This pricing basis contributes to overfishing currently being experienced in Palawan because of the preference for smaller "tropical" fish that can be caged and grown to marketable size in 3–4 months.

5. Value Retention at the Fisher and/or Cager Level

To complete the analysis of value retention, the study analyzed the costs and revenues of fishing and caging (Table 41).[66] Revenue was computed using a "base situation," which is representative of the current operational and catch parameters of the handline fishery. The base situation is defined as follows: (i) CPUE for Taytay at 0.30 kg per fisher-hour and Quezon at 0.33 kg per fisher-hour; (ii) level of effort in Taytay is 4 hours per day, 20 trips per month, and 12 months per year; while that in Quezon is 120 hours per trip or 5 days, 4 trips per month, and 12 months per year; (iv) disaggregation of catch based on data in the section on Overview of Live Reef Fish Fishing in Taytay and Quezon and Table 41; and (v) price differentiation.

In the base situation, the average annual revenue for each handline fisher is around P70,000 ($1,590) for Taytay and P267,000 ($6,136)[67] for Quezon. This translates into some P6,000 per month for a handline fisher in Taytay and P22,000 for a handline fisher in Quezon. As Quezon is a new player in the LRF trade, and is still learning new techniques in the trade, it is not surprising that 85% of the revenue in Quezon is contributed by catch other than groupers; while in Taytay, 38% of revenue comes from live groupers for the export market. The base situation would satisfy the poverty threshold levels for Palawan and even in Taytay.

The cost per trip was computed from the mini survey conducted by WWF-Philippines and was based on the operating cost per trip (diesel, gasoline, food, ice, bait, hooks, and other implements). Repairs and depreciation were also estimated, with the latter based on investment costs ranging from P1,500 to P80,000 for boats. For the survey, the average value was P14,500, which was used to compute the cost per trip. Using 240 trips per year and 4 crews per trip, the cost of 1 trip in Taytay was estimated at P724, almost similar to the cost estimated by Padilla et al. (2003) for Coron (P672). In Quezon, the average investment cost was higher (P73,000), although the boats were all less than 1 gross ton. Informants reported that their boats were equipped with fish-finders and aquariums, while at least two informants said they

[66] More details on the cost and revenue analysis could be obtained from WWF-Philippines, through Mavic Matillano or Joel Palma.
[67] Exchange rate used is $1 = P44.

Table 41 **Revenue Estimates from Handline Fishing in Taytay and Quezon, Palawan, Philippines**

Revenue Parameters	Taytay (kg)	Quezon (kg)	Price (P/kg unless stated otherwise)	Taytay Revenue (P)	Quezon Revenue (P)
Average catch per handline fisher	288	2,376			
Average catch of groupers	80.6	63.4			
Average catch of other species	177.8	2,269	100	17,784	226,908
Average catch of invertebrates	29.5	42.8	100	2,952	4,276
Live groupers	78.4	38.8			
Fresh groupers	2.2	24.6	300	668	7,384
Good-sized groupers	14.5	11.0	1,800	26,192	19,447
Undersized groupers	47.0	2.8	300	14,109	853
Oversized groupers	2.5	24.8	300	738	7,500
Unclassified	14.37		50 per piece	7,187	
Total Annual Revenue				**69,630**	**266,818**

kg = kilogram.
Source: Trinidad (2011b).

had compressors. The operating cost was about P7,500, estimated 10 times that of Taytay since each trip in Quezon lasts for 5 days. The costs covered diesel, gasoline, kerosene, ice, food, coffee and juices, cigarettes, nylon rope, bait, *cristalet*, chicken feathers, and charcoal. The depreciation cost was computed at P1,200 per trip. No data on repairs were provided.

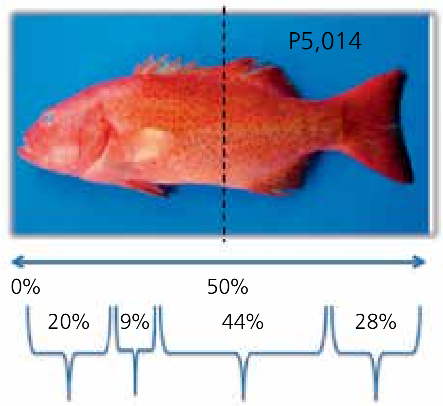
Using the cost data, the net revenues for handline fishing were based on the number of trips made. On average, they made 240 trips in Taytay (20 trips/month, 12 months/year) and 60 trips in Quezon (5 trips/month, 12 months/year) (Table 42). In the case of Taytay, pure handline fishing (without resorting to caging of juveniles) does not make good economic sense as P29,000 per year does not meet the poverty threshold requirements for a family of 6. However, in Taytay, all fishers were cagers and vice versa. Thus, after caging juveniles, accounting for the feeds and a

Table 42 **Net Revenue Estimates from Handline Fishing, Taytay and Quezon, Palawan, Philippines**

Parameter	Taytay (P)	Quezon (P)
Annual revenue, base situation	69,631	266,818
Cost per trip	672	8,700
Cost per kilogram	560	877
Cost per fisher/year	40,320	174,000
Net revenue	29,311	92,818
Add: Revenues from caging	71,720	5,371
Total	**101,032**	**98,189**

Source: Trinidad (2011b).

Figure 29 Value Distribution along the Live Reef Fish Chain



Source: Trinidad (2011b).

mortality of 30%, and imputing a price for the juveniles, the revenues from caging were higher than from fishing, mainly because of premium prices obtained for the fish.

6. Value Distribution for Entire Live Reef Fish Chain

The value chain distribution is depicted in Figure 29. The final value of P5,014 is the peso equivalent of the average retail price in Hong Kong, China, and is distributed across the chain based on prices received.

The wholesaler captures almost half of the value while the fisher and/or cager captures 20%, and the retailer 28%. Assuming that the exporter acts as an agent of the wholesaler (and this is reportedly the case), value retention at the country of source is 20% while the rest of the value is absorbed by the importing country. Of the 20% value retained in the source country, 30% is the value-adding contribution (cost of feeds, cage, permits, and labor) while 70% is the margin. This estimate considers the fisher and/or cager as one entity. Pure handline fishing in Taytay will result in losses, while Quezon will remain profitable because more than 50% of catches consist of other fish species and invertebrates. When handline fishing is coupled with caging, as is the case in Taytay, the net revenues exceed that in Quezon because fishers and/or cagers are able to take advantage of the high prices of live grouper.

The literature suggests that the wholesalers in Hong Kong, China are the price leaders, who influence downstream prices from supply economies by maintaining financial support to the shipper or importer. Petersen (2007) observed that in aggregate, retail and wholesale prices in Hong Kong, China and beach prices in the source economies are integrated, or those prices move synchronously in the long term and vary simultaneously as part of a single market. The study also concluded that wholesale prices in Hong Kong, China tend to influence retail pricing, but not vice-versa; and established that wholesale pricing is the price leader in the LRF trade. Presumably, retailers allow wholesalers to set prices based on supply costs, including risk and uncertainty. Their financial support to intermediaries in supply countries allows them to set prices upstream, while the disproportionate costs and risks associated with that stage of the supply chain allow them to set prices for downstream agents as well.

7. Conclusions

Value chain analysis provides a broad perspective for an analysis of traded commodities such as LRF. The analysis shows that one-fifth of the value is retained in the source country. However, whether this is a fair share will depend on how other commodities fare; and, more importantly, whether the value-adding contribution is well rewarded. Margins earned by cagers can reach up to 70% of the total beach price and net earnings, and this is consistent with previous studies on incomes of LRF cagers (Cola et al. 2009, Padilla et al. 2003). At Palawan's annual per capita poverty threshold of P14,308, a family of 6 would need about P64,000 to meet basic needs and breach the poverty threshold. This threshold can be met by fishers and/or cagers.

While the economic objectives may have been achieved, the pricing nuance in LRF hastens the exploitation of juvenile fish. The price difference in catching oversized fish, as opposed to plate-sized ones, detracts from efforts to restrict the catching of small fish. Catching juveniles means earning immediate cash (P50–P75 per piece) or caging them and earning the premium price after a fattening period of 3–4 months.

There are three points to consider. First, the catching of juveniles must be contextualized in the larger production possibility scenario, which includes catching good-sized fish. Trinidad (2011b) explained that as the ratio of good-sized fish improves (and the ratio of juveniles decreases), annual revenues for handline fishers would increase by 17% from the current rate of 18%–28%, and another 30% as the good-sized fish increases to 50%. Second, the caging of juveniles also needs to be costed appropriately. A cager and/or investor would only look at the feeds (cheap trash fish at P30/kg), labor inputs that are often unvalued, and risks of mortality and theft. However, it is incumbent on the resource manager to account for "unseen costs," including the use of space for cages (usually sited near coral reefs), loss of aesthetics, conflicts with navigation and other fishing activities, tourism, and pollution. Third, the continuous practice of caging juveniles will result in a further drop in CPUE as this is clearly an indication of growth overfishing. The second and third arguments are not realized by the fisher or cager, but should be recognized from a management viewpoint. Additional insights concerning pricing integration in the LRF trade are provided by Petersen (2007), who concluded that wholesale demand for leopard coral grouper is inelastic if in terms of their own prices but elastic in terms of income levels.

The demand and pricing scenario for LRF is contingent on the income levels in the importing economy. In Hong Kong, China, the severe acute respiratory syndrome (SARS) scare and the Asian economic crisis resulted in dipping demands and prices. Conversely, periods of stable income increase the demand for fish, especially high-value species. Based on gross domestic product (GDP) data from Hong Kong, China, the study derived year-on-year growth trends and compared them with year-on-year growth trends in fish imports. Results showed that importation patterns follow the general trend in GDP, although there is a 2-year lag. The correlation was 45%, which confirmed that demand (as evidenced by importations) is influenced by general income levels. Petersen (2007) affirmed the findings of Gaiger (1990) by concluding that demand for LRF is influenced more by income levels rather than by fish price, thereby conferring on it the status of a luxury good. Thus, price increases will not likely depress the demand as long as incomes are increasing.

A summary of phased interventions resulted from these LRF studies, of which the value chain is one. Stage 1 focuses on enhancing marine protected area (MPA) management. It is said that a square kilometer (km^2) of reef area saved is equivalent to 0.5 t of groupers harvested from non-MPA areas. MPAs are popular, with positive demonstration effects already known to communities; however, proper site selection is also required and the areas of spawning aggregation comprise one of several criteria. With some external technical assistance, local governments may be well-equipped to implement MPAs. Stage 2 involves a comprehensive registration of fishers and boat owners to identify the users, exclude outsiders, and control the sharing of accreditation. Stage 2 is more difficult to enforce, especially among the voting population; and limiting outsiders can only be successful if monitoring and enforcement exist. Stage 3 involves stricter enforcement of policies, while Stage 4 utilizes economic instruments as incentives or disincentives for the catching of juveniles. One recommendation is to price the use of waters for caging according to the number of months the fish is caged, i.e., the longer the caging period, the higher the fee. This is to dissuade fishers from catching juveniles and polluting the waters as a result of feeding the fish. Appropriate pricing of licenses is also needed and pricing should reflect the correct valuation of ecosystem services and the scarcity of resources.

D. A Simple Value Chain Analysis for Coral Exports in Solomon Islands

1. Background

This section summarizes the key findings of a study on coral trade in Solomon Islands, including an analysis of value chains (Trinidad et al. 2012). The full report evaluates coral trade and its contribution to economic development, food security, and biodiversity conservation in Solomon Islands. It forms a series of reports prepared by WorldFish and this project as part of a study entitled *Economic Valuation of Coral Reefs and Development of Sustainable Financing Options in Solomon Islands,* supported by the Australian government's Department of Sustainability, Environment, Water, Population and Communities.

Existing reports point to a modest (Albert, Schwarz, and Hawes 2010) significant contribution (Teitelbaum 2007) to rural incomes in Solomon Islands from the coral trade. The cash generated from trade aids the slow but sure shift of communities to a cash economy. Thus, trade policies on the export of corals have implications on how the government perceives its contribution as a rural engine of growth, i.e., income and distributional effects. It should be validated if the impacts on rural economies are substantial, or if the costs, including that of the environment, far outweigh the economic returns; and in the case of coral trade, whether value retention is beneficial to the country that extracts the goods.

2. Overview of Coral Trade

Solomon Islands is the fourth top supplier of corals in the world after Indonesia, Fiji, and the Philippines. In 2005, it accounted for roughly 4% of the global market for aquarium and curio products used in public and private aquariums of hobbyists, and as jewelry and other items (Lal and Kinch 2005).

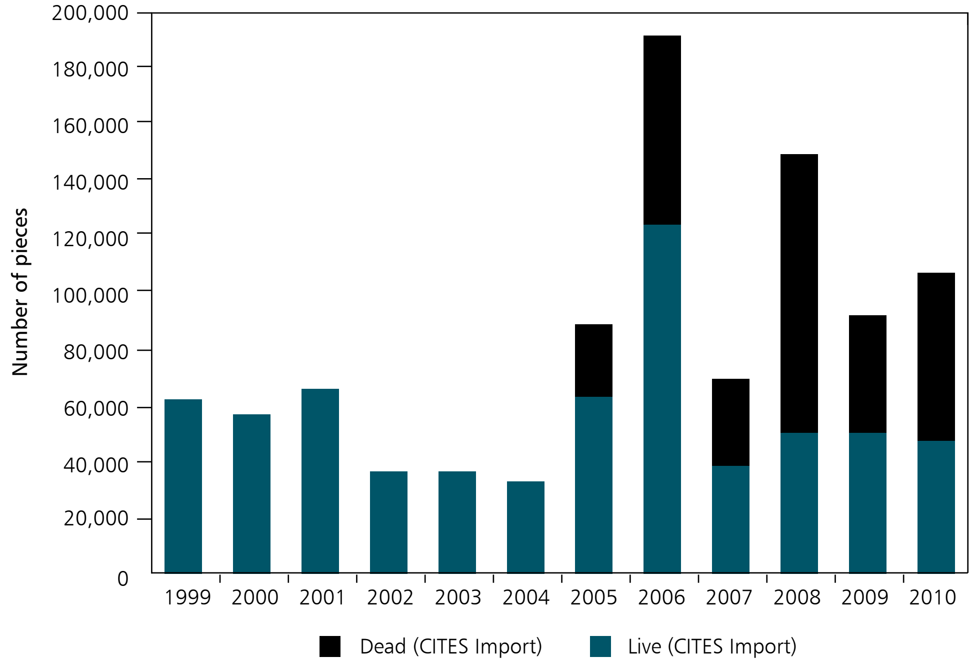
Prior to Solomon Islands becoming a signatory to the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES) in 2007, aquarium trade was first enabled by the Fisheries Act, over which the Department of Fisheries and Marine Resources (DFMR) (now the Ministry of Fisheries and Marine Resources [MFMR]) had jurisdiction. The Department of Forestry and Environment (now, the Ministry of Environment, Climate Change, Disaster Management and Meteorology [MECDM]) issued the necessary wildlife permits. Upon accession to CITES, the institutional arrangements were clarified, with the management authority resting on MECDM, while the scientific authority was given to the MFMR. In CITES rules, this means that MECDM is responsible for the issuance of permits and certificates under the terms of CITES, while MFMR determines whether the export is detrimental to the survival of the species in the wild. Upon accession to CITES in 2007, 134 species of corals from Solomon Islands appeared on the IUCN Red List of Threatened Species; and in the following year, 503 species of hard corals were likewise listed.

There are quotas for the export of corals, clam shells, and dolphins. Coral exports were promoted as a way of broadening livelihood sources of coastal communities in the mid-1970s, but it was not until the 1990s when coral exportation started in earnest. The Solomon Islands Marine Export, started by David Palmer, was the pioneer exporting company. He later left and established the Aquarium Arts Solomon Islands (AASI); and, today, the two companies export the vast majority of live animals bound for the aquarium trade. Eventually, the two companies specialized, with the Solomon Islands Marine Export focusing on coral ornamentals and AASI on aquarium fish. There is one exporter for the aquarium trade (AASI) and two exporters for the curio trade (Halelo and Sea Abundance) (Albert et al. 2012).

The coral trade discussed in this report involves the harvesting or extraction of corals as live specimens, which are then either shipped live for the international aquarium trade or left ashore to die and bleach in the sun before being shipped as dead coral for the curio trade. The live coral trade involves the extraction of live corals from a reef before packaging and transporting them live, internationally by air, in sealed insulated boxes. These corals end up in domestic or commercial aquariums throughout the world. The curio trade (commonly referred to as the dead coral trade) began in 1984, before it was stopped by the government in 1994 and reopened in 2003 (Lal and Kinch 2005).

The curio trade involves the harvest of live corals (primarily *Acropora sp*.) from the reef—from small (less than 25 centimeters [cm] in diameter) to large coral pieces (greater than 80 cm diameter)—which are then placed under the sun to die and be bleached white. The bleached corals are sent to exporters in Honiara prior to shipment in containers to overseas buyers, often ending up as decorations in large hotels (Albert et al. 2012). Dead corals for the curio trade usually include the following genera: *Acropora, Pocillopora, Turbinaria*, *Heliopora,* and *Seriatopora*. Preferred species for the live trade belong to the following genera: *Euphyllia, Acropora, Montipora, Sarcophython, Sinularia, Ricordia,* and *Fungia* (Teitelbaum 2007). The same species of hard coral are exploited for the live and dead trade except that for dead trade, larger sizes are required, sometimes entire colonies (Lovell 2001). From 1999 to 2010, an average of 74,000 pieces of corals (MFMR data) and 102,000 (CITES data) were exported. The MFMR started recording both live and dead coral exports only in 2005 (Figure 30a), while CITES monitored both live and dead corals during the entire period (Figure 30b). Both MFMR and CITES data show an increasing percentage of dead corals in the total coral exports.

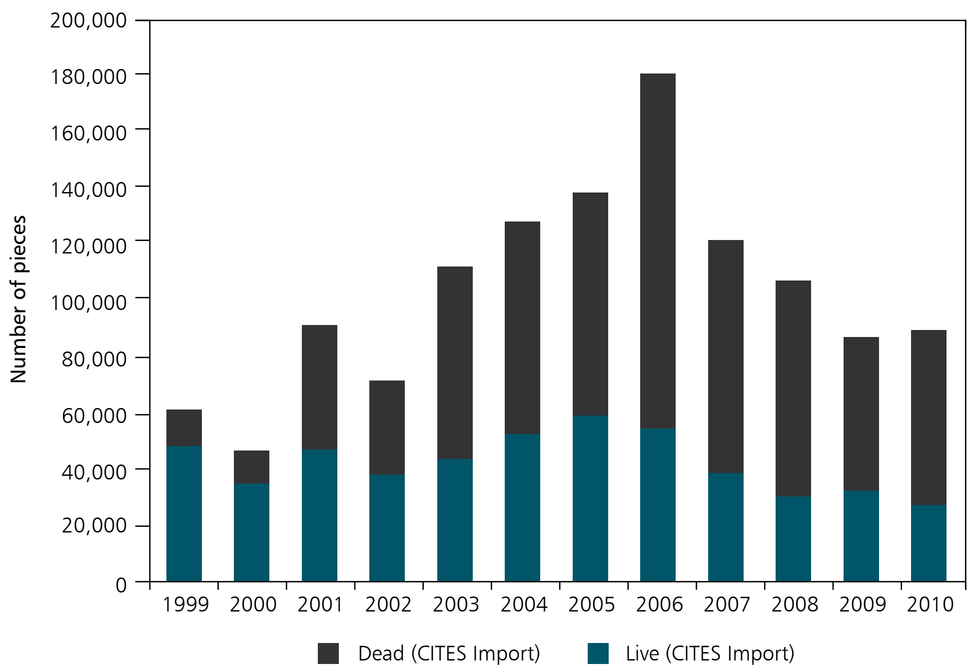
Figure 30a **Coral Exports from Solomon Islands, 1999–2010 (based on Ministry of Fisheries and Marine Resources data)**



CITES = Convention on International Trade in Endangered Species of Wild Fauna and Flora.

Source: Ministry of Fisheries and Marine Resources (2012).

Figure 30b **Coral Exports from Solomon Islands, 1999–2010 (based on CITES data)**



Source: Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES) (2012).

Over time, the coral market has grown in terms of trading partners (Table 43). The peak was nine trading partner economies in 2002. In 2005, France and Italy combined imported close to 12,000 pieces of corals. By the end of 2010, the number of importing economies declined to five with the United States and Japan remaining as the largest importers.

Coral farming was introduced in Solomon Islands in 1997 by the International Center for Living Aquatic Resources (ICLARM), now WorldFish; and the Foundation of the Peoples of South Pacific International, as a means to thwart destructive practices and overharvesting of live reef organisms. Farming of giant clams and corals ceased during the period of ethnic tension in the country; but by 2000, trade in farmed coral resumed. Lal and Kinch (2005) noted that farmed coral exports accounted for only 1.6% of total volume of exports in 2000–2005. Economies of scale at the village level should be achieved if coral farming is to be accepted as a viable alternative to wild harvesting. If the government recognizes the need to shift from wild harvesting to farming to ensure long-term ecosystem services provided by reefs, certain financial constraints have to be addressed. These include the (i) development of culture operations on a larger scale; (ii) cost-efficient transport to Honiara, such as by sharing with other sectors and products and consolidation of products; and (iii) better pricing (Teitelbaum2007).

3. Value Chain Analysis

Value chain actors are individuals and enterprises performing the basic functions of a value chain. In the aquarium and curio trade, they include the village harvester, exporter, importer, wholesaler, retailer, and consumer. The last three participants are based in the importing country, while the collector and/or harvester and the exporter are based in Solomon Islands. There may be additional actors in this chain, such as entrepreneurs, between the village harvester and the exporter; and there may be multiple enterprises involved in the import and wholesale sectors.

Lal and Kinch (2005) described the harvesting and processing of corals for exports, while Teitelbaum (2007) quantified coral harvests and exports. The work of Lal and Kinch was based largely on coral exporting in Fiji, where the process may not be entirely the same as that in Solomon Islands, but may be instructive as well. The coral harvester starts the supply chain by collecting corals. Collectors do not harvest everyday, but organize trips at least once a month or about 14–22 trips per year. Each boat carries 2 or 3 persons, usually from the same family or clan. Their equipment includes knives, fins, chisels, baskets, and canoe. No scuba equipment is used, which also limits the frequency of operations or duration of dives. Teitelbaum (2007) estimated that a village collection group from Leitongo can potentially harvest 2,000 pieces of corals per week or about 96,000 pieces on a yearly basis. It is apparent that Solomon Islands can export at least twice as much as the current level of 70,000 pieces per year, and this occured in 2006 when more than 150,000 pieces were exported.

Collectors targeting the curio trade perform the same functions, although the selection and collection of specimens may take a little longer because larger corals or entire colonies are harvested, and more caution is exercised to ensure that no breakage occurs.

Due to the paucity of data on coral and aquarium trades, a simple value distribution analysis was undertaken to understand how much of the “end coral value” goes to the village coral harvester (for the wild harvest coral aquarium and curio trades). For the aquarium trade, the average price for a small, wild-harvested coral was used. The village harvester receives

Table 43 Coral Trade Partners of Solomon Islands, 1990–2010

Year	United States	New Zealand	Germany	Hong Kong, China	Spain	United Kingdom	France	Denmark	Canada	Republic of Korea	Singapore	Switzerland	Italy	South Africa	Japan
1990	x	x													
1991	x	x													
1992	x	x													
1993	x	x	x	x											
1994	x	x		x											
1995	x	x	x	x											
1996	x	x	x	x											
1997	x	x	x	x											
1998	x	x	x	x	x										
1999	x	x	x	x											
2000	x	x	x	x		x									
2001	x	x	x	x		x	x	x							
2002	x		x	x		x	x		x	x	x	x			
2003	x		x	x						x	x		x	x	
2004	x	x		x									x		
2005	x	x		x			x						x		
2006	x					x							x		x
2007	x					x							x		x
2008	x	x		x		x							x		x
2009	x					x									x
2010	x	x		x		x							x		

Source of secondary data: ADB. 2013. *Regional Cooperation on Knowledge Management, Policy, and Institutional Support to the Coral Trade Initiative.* Consultant's Report. Manila (TI 307-REG).

Table 44 Comparison of Prices of Corals in Solomon Islands with Average Retail Prices in the United States, 1999

Species	FOB Prices ($/pc)	Average Retail Prices Collected from Seven Retail Outlets in the US, 1999[a] ($/pc)			Internet-Listed Prices as of June 2012[b] ($/pc)
	Average or Range	Small (S)	Medium (M)	Large (L)	
Acropora spp.	4.00	40	53	73	43.99 (S)
Catalaphyllia spp.					
C. Jardinei	6.00–14.00	37	53	78	
Euphyllia spp.		22	28	33	
E. paradivisa	2.50–4.00				
E. ancora	4.00				
E. glabrescens	3.00				
Goniopora spp.	2.00–2.50	26	30	36	Branch Goniopora, 47.23 (S)
Heliofungia spp.	2.50	25	33	38	
Lobophyllia spp.	2.50–5.00	23	32	37	Colored teeth, 43.95 (M)
Nemenzophyllia spp.	2.50–4.00	27	32	38	
Plerogyra spp.	3.50–5.00	23	31	39	Bubble cat-eye, 43.99 (S)
Porites spp.	2.00–5.00	31	45	63	
Trachyphyllia spp.	2.00–5.00	26	38	41	Brain coral, 39.99 (S)

FOB = free on board, US = United States.
Sources:
[a] Green and Shirley (1999).
[b] http://www.bluestaraqua.com

SI$2.50 per piece, the exporter sells to the importer and/or wholesaler for SI$23.40 a piece, and the same-sized piece of coral is retailed at SI$234.[68]

Export prices of a selection of corals, based on data from AASI, were compared with retail prices in the US based on 1999 data from Green and Shirley (1999) and data from www.bluestaraqua.com (Table 44). The species that were compared may be different species within the same genus, and accuracy across a particular species may be hard to establish. Nevertheless, what is of interest in this analysis is the huge disparity between free on board (FOB) prices in Solomon Islands and the retail prices by a factor of at least 10 for almost all species listed. This could be partially explained by the costs associated with transport and marketing, although only full value and/or supply chain analysis can assess whether costs and/or margins are excessive.

For the curio trade, the average price for a medium-sized wild-harvested coral was used. The village harvester receives SI$8, the exporter sells to the importer and/or wholesaler for SI$33, and the same-sized coral retails at SI$312. As the wholesaler's selling price to the retailer was not available, the price was estimated at SI$120 but did not include value adding or costs incurred by each of the actors in the supply chain. Similar to the aquarium trade, the curio village harvesters receive an extremely small proportion of the value (2%), although this is double that of the aquarium trade.

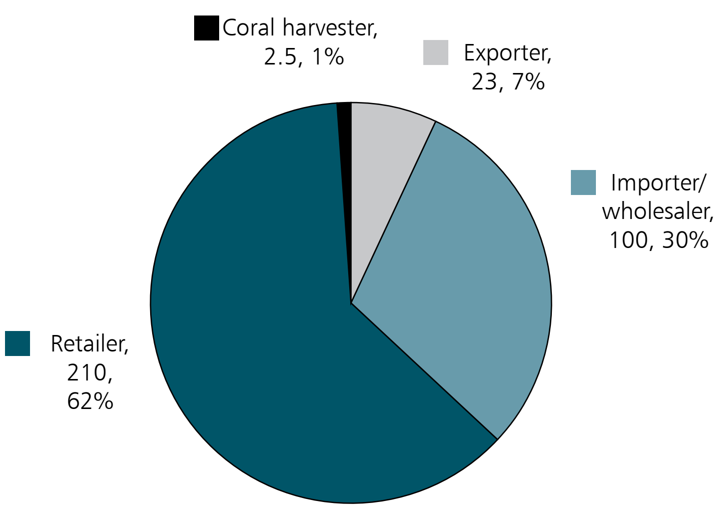
[68] Exchange rate used: SI$7.28 = $1.00, November 2011.

On average, each piece of coral is sold for $30 or about SI$210. Thus, the value that is retained in Solomon Islands is the value derived by the collector, i.e., SI$2.50; and the export price can range from SI$8 to SI$33. The value retained in the country ranges between 12% for live corals and 19% for dead corals, consisting of the values earned by the village collector and the exporter (Figures 31 and 32). The exporter earns 11%–16% of the total value, which is the basis for the Government of Solomon Islands to impose a 10% export tax. In effect, the government has a 10% share of the exporters' share. Values earned by the village collector range from 1% for live coral collection to 4% for curio. The importer and/or wholesaler and retailer take the largest part of the value. While no data on costs were readily available for this study, it is expected that the capital requirement of both wholesalers and retailers would be huge. First, they would pay for insurance and freight costs, holding tanks, domestic transport, and labor. Second, the risks of breakage for dead corals and mortality for the live corals are high. The work of Green and Shirley (1999) confirmed the huge disparity in the value generation of the coral trade between exporting developing countries and retailers in the US, with collectors and/or harvesters earning just $5 million from the trade and retailers making at least $50 million in 1999.

4. Implications of Coral Harvesting at the Community Level

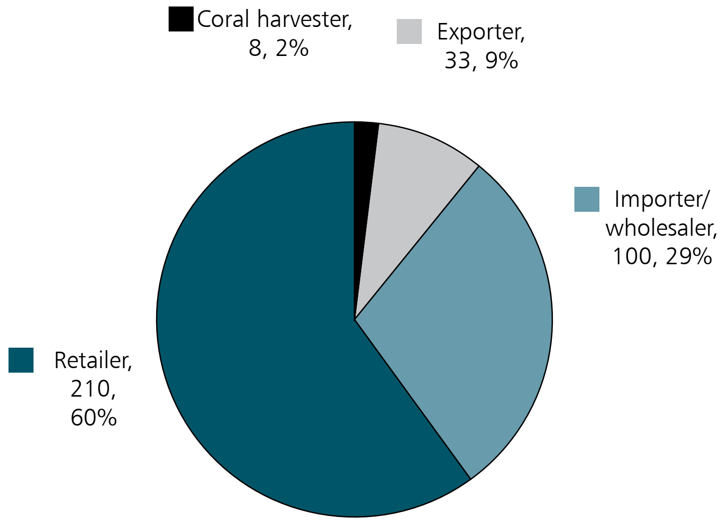
The potential for coral harvesting to contribute to household income was assessed using data for daily household expenditure from the United Nations Development Programme (UNDP) Household Income and Expenditure Survey for Solomon Islands (UNDP Pacific Centre 2008). Summary statistics for daily per capita expenditure on food and nonfood items are shown in Table 45.

Figure 31 Value Distribution of Live Coral Exports in Solomon Islands



Source: Authors.

Figure 32 **Value Distribution of Dead Coral Exports in Solomon Islands**



Source: Authors.

Table 45 **Impact of Coral Collection Scenarios on Nonfood Expenditures**

Item	Daily Expenditure Requirements (SI$) Food	Daily Expenditure Requirements (SI$) Nonfood	Household Size (No. of Persons)	Collection Level Scenarios and % of Nonfood Expenditures Covered: 5 pieces/day	10 pieces/day	15 pieces/day
National average	32.59	14.66	6.2	0.69	1.37	2.06
Rural	27.48	12.09	6.0	0.86	1.72	2.58
Total coral collection required (pieces/year)				60,000	120,000	180,000

Source: Trinidad et al. (2012).

To estimate income from coral collection, three scenarios for coral collection were assumed: 5, 10, and 15 pieces of coral per collector per day multiplied by SI$2.5, the average price received per piece. The 5-piece/day scenario is equivalent to an annual collection of 60,000 pieces, while the 10-piece/day scenario amounts to 120,000 pieces, similar to current export levels. Based on these scenarios, a coral harvester could earn from SI$62.50 ($8.50) per week for a 5-piece daily collection to SI$187.50 ($25.70) per week for a 10-piece daily collection. This comprises less than 3% of daily nonfood expenditures under all scenarios. A 5-piece daily collection over 22 weeks yields almost $200, while a 10-piece daily collection yields $600. This is comparable with the estimates by the WorldFish Center (2010) of SI$500–SI$2,600 ($60–$320) per year, contributing 20%–80% of household cash needs that include both food and nonfood expenditure requirements.

5. Conclusion

An assessment of coral trading patterns showed the maturity of the coral export trade from Solomon Islands, which had five economies as trading partners in 2010. None is more important than the US, which absorbs more than 90% of the country's coral exports. Thus, US trade policies and demand for coral products will greatly influence continued practices in Solomon Islands. Over time, the curio coral trade has become the most significant component of coral export trade.

Of the total value of coral exports, less than 5% is retained by the fisher and/or harvester and another 10% with the exporter. The lower price paid to Solomon Islands may be partially explained by the costs of transport and marketing, although a detailed value chain analysis would be required to assess whether costs and/or margins are excessive. Nevertheless, the analysis shows that the coral trade is an important source of cash income at the community level and that a portion of their nonfood requirements may be covered from this source. Despite the modest amounts, the shift to a cash economy highlights the desire to generate cash income. To add value to Solomon Islands coral trade, one option is to market sustainably farmed corals, which would require a premium price and government export subsidies.

Learning about the nuances of coral trade can inform policies that should guide the government. There are potential earnings that can be derived from trade, which can contribute to national income and livelihoods and provide cash income for communities. Hence, decisions on coral trade must be evaluated under the larger framework of benefits derived from corals and coral reefs, including benefits accruing to the subsistence sector and those derived from coastal protection.

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VII. Assuring Sustainable Fisheries Development

Reniel Cabral,[69] Porfirio Aliño,[70] Robert Pomeroy,[71] and William Jatulan[72]

A. Importance of Fisheries in the Coral Triangle

The Food and Agriculture Organization of the United Nations (FAO) defines food security as a condition "when all people, at all times, have physical, social, and economic access to sufficient, safe, and nutritious food that meets their dietary needs and food preferences for an active and healthy life" (FAO 2011). Quality and safety aspects of food have also been regarded as important components of food security. In the Coral Triangle, the countries agreed to apply the following definition of food security:

> Improvement in the affordability, availability, and quality and safety of food sourced from the coastal and marine environments. Indicators of affordability include the income of fishers, price of basic commodities, and community resiliency or social well-being. Indicators of availability include food sufficiency of fishing household and food consumption of coastal communities. Indicators of quality and safety include contribution of fish to protein requirement and the health of fishing communities.

Despite the importance of the Coral Triangle as a world supplier of fish, food security in the region remains a challenge. Food security issues were exacerbated, according to Foale et al. (2013) and Cabral et al. (2013), by a myriad of anthropogenic and climatic threats. Hughes et al. (2012) evaluated national vulnerability of fisheries, reef management, and food security to climate change in 27 countries. It included the three Coral Triangle Southeast Asia (CT-SEA) countries—Indonesia, Malaysia, and the Philippines. Of these three countries, Indonesia was ranked as the most vulnerable to climate change and the Philippines was ranked fifth, while Malaysia was the least vulnerable. The CT6 countries also have high socioeconomic vulnerability, considering that 16.6% of their total population are poor, and about 13% are undernourished (Table 46).

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[69] Footnote 4, p. 5.
[70] Decision Support System Specialist.
[71] Professor, University of Connecticut, United States.
[72] Regional Coordinator, US CTI Support Program.

Table 46 **Poverty and Undernourishment in CT6 Countries**

Country	Population[a] (2011)	Number and % of Population below National Poverty Level[b]	Undernourished in the Population (2005–2007)	
			No.	%
Indonesia	241,600,000	32,132,800 13.3% (2010)	31,408,000	13.0
Malaysia	28,990,000	1,101,620 3.8% (2009)	579,800	2.0
Papua New Guinea	7,000,000	2,590,000 37.0% (2002)	1,820,000	26.0 (1995–1997) (see note below)
Philippines	94,200,000	24,963,000 26.5% (2009)	14,130,000	15.0
Solomon Islands	540,000	122,580 22.7%[c] (2006)	59,400	11.0
Timor-Leste	1,092,000	544,908 49.9% (2007)	338,520	31.0
Total	**373,422,000**	**61,454,908 16.5%**	**48,335,720**	**12.9**

Note: The general trend for the proportion of undernourished in the population is declining in the region, and this value is potentially higher than its value for 2005–2007.

Sources:

[a] ADB (2011).

[b] Millennium Development Goals. United Nations Statistics Division.

[c] Solomon Islands National Statistics Office and UNDP Pacific Centre (2008).

Poverty incidence in the coastal fishing communities of CT6 countries is generally higher than the national average. In the Philippines, 49.9% of the fishing households are below the national poverty line (Castro 2009) compared with 26.5% at the national level. In Timor-Leste, poverty, malnutrition, and access to animal food sources (e.g., livestock and fish) are the main issues being addressed by the government since the country's independence in 2002 (MAF 2012). In many of the Pacific island countries, food importation is increasing because of the declining per capita production of food caused by rural–urban migration and changing food preferences (Sharma 2006). Malaysia, although currently food secure, heavily relies on imports of fish to support the consumption and needs of its population, which makes the country susceptible to fluctuations in the supply of fish from other countries.

There are many sources of vulnerabilities in coastal fishing communities, which are usually excluded or not given much attention in social, human, and economic development programs. Often, stakeholders are disadvantaged in economic transactions, making them vulnerable to marginalization. This highlights the importance of having HSU avoids cliches and jargon such as these; recommends "equal treatment" through enabling conditions for social enterprises, fair trade policies, and social marketing that will minimize the asymmetry of information and improve transparency and accountability in fisheries governance.

As shown in the value chain analysis of tuna, live reef fish food trade, and coral trading in Chapter VI, the most value-adding contribution of trade is retained by the wholesaler or retailer.

For example, in coral trading in Solomon Islands, a mere 1%–2% of the value of exported corals is retained by coral harvesters. Signs of fish supply deficit in CT6 countries are also apparent. The contribution of fish to the dietary energy requirements of Indonesia and the Philippines is below the recommended level (Cabral et al. 2013). The per capita fish consumption in Papua New Guinea (PNG) and Solomon Islands is currently below the standard requirement to satisfy their present and future dietary protein needs (Bell et al. 2009). Fish provides more than 30% of animal protein consumed by people in the region. In Indonesia and Solomon Islands, it is more than 50% (Table 47). In the Coral Triangle, with a population of 373 million, 16% of whom live below the poverty line, the average fish consumption is about 20 kilograms (kg) per capita per year and higher in coastal communities. In Malaysia, fish consumption is 60.2 kg per capita per year in 2000–2002 (Table 47).

Small-scale fishing, which accounts for the bulk of jobs in the sector in the Coral Triangle, is much more significant as a source of livelihood, food security, and income than is often realized. In terms of the estimated distribution of small fishers across Asia, approximately 38% are from Southeast Asia. It is estimated that when full-time, part-time, and seasonal men and women fishers are included, there may be more than 15 million small-scale fishers in the Coral Triangle. In addition to the fishers, many other people rely on small-scale fisheries for their food and livelihood. While no accurate estimates are available for Asia and the Pacific, but assuming an average of 5 as household size, 75 million people in the region are directly dependent on fisheries for food, income, and livelihood. Small-scale fishing is estimated to create at least another two jobs for every fish worker. Using this assumption, it is estimated that fish production in the region employs some 30 million people in associated sectors, such as marketing, boatbuilding, gear making, and bait production.

Marine capture fisheries production is not expected to keep pace with demand, creating concerns for food security in the region. The increasing demand for fish from the expanding and urbanizing population will create more stress on the already declining coastal and inshore fishery resources in the region. Small-scale fisheries exploit many of the same stocks fished by commercial fisheries, as well as the smaller nearshore stocks. Many of the fisheries on which small-scale fishers depend are already showing signs of collapse as a result of increasing overexploitation of fisheries and habitat degradation.

In South and Southeast Asia, coastal fish stocks have been fished down to 5%–30% over the last 5 decades, threatening fishers' incomes, employment, revenues, trade, and social stability. Many small-scale fisheries in Asia have an excessive level of factor inputs (capital and labor) relative to that needed to catch available fish. In the Philippines, for example, an estimate shows that, for the demersal and small-scale pelagic fisheries in shallow coastal waters in the mid-1980s, the level of effort was 150%–300% of that needed to gain the maximum economic yield, resulting in a wastage of $450 million per year. In the Pacific, population growth and the need for cash income have led to the overexploitation of coral reefs; and the lagoons and shores are being threatened by pollution, siltation, and construction of coastal infrastructure.

Access to or exclusion from fisheries resources may influence the vulnerability of people to poverty and food insecurity. Production from coastal capture fisheries in the region will decline over the next 10–20 years unless excess fishing capacity and fishing effort are greatly reduced (Pomeroy 2012). Prospects for increasing catches are further dimmed by some fishing methods used by small-scale fishers, such as cyanide and explosives, which have had devastating impacts

Table 47 Socioeconomic Fisheries Statistics of CT6 Countries

Indicator	Indonesia	Malaysia	Papua New Guinea	Philippines	Solomon Islands	Timor-Leste	Asia	Oceania	World
Fish supply (2007)(t)[a]	5,460,553	1,489,953	103,692	3,138,560	16,734	4,024[b] (2004 data)	75,207,046	868,210	114,026,910
Per capita fish supply (kg/person/year) (2007)[a]	24.3	56.1	16.1	35.4	33.6	4.4[b]	18.7	25.2	17.1
Fish protein (g/capita/day) (2007)[a]	8.0	17.1	5.2	11.3	11.6		5.1	6.5	4.8
Animal protein (g/capita/day) (2007)[a]	15.3	39.0	40.2	25.3	15.3		23.1	61.9	29.6
Total protein (g/capita/day) (2007)[a]	56.7	77.9	75.5	60.0	52.1		72.5	97.8	77.3
Fish and/or animal proteins (%) (2007)[c]	52.5	43.8	12.9	44.7	75.7		22.3	10.4	16.1
Fish protein as a % of total protein supply (2007)[c]	14.1	21.9	6.9	18.9	22.2	see note	7.1	6.6	6.2
Fish consumption (kg/person/year)[c] (Average 1990–1992)	15.33	48.18		35.41	45.63				
Fish consumption (kg/person/year)[c] (average, 1995–1997)	18.98	55.85		29.93	41.25				
Fish consumption (kg/person/year)[c] (average, 2000–2002)	21.54	60.23		29.20	31.03				
Fish consumption (kg/person/year)[c] (Average 2005–2007)	23.36	51.10	13[d]	32.49	31.03	see note			

g = gram, kg = kilogram, t = ton.

Note: FAO fish protein statistics for Timor-Leste were not presented since they do not coincide with some country reports.

[a] FAO (2010).

[c] FAO (2012b).

[b] FAO (2012a),

[d] Bell et al. (2009).

Source: Data from Cabral et al.(2013, supplementary file).

on coastal fisheries, fish habitats, and the health and welfare of fishing households. Although the men are more often maimed from explosives and disabled as a result of gearless diving, the women of the households are the ones who shoulder the burden of caring for these men and increasing their own income-earning activities to replace the lost income. Meanwhile, the increasing tendency to shift to aquaculture will increase the demand for trash fish; thus, exerting more pressure on capture fisheries and resulting in habitat conversion, pollution, and siltation arising from artificial feeding method and resource-use conflicts. Although new opportunities are emerging, the sector should learn lessons from past mistakes.

B. Key Drivers Affecting Fisheries Ecosystem Sustainability

Several drivers of change are affecting the sustainability of fisheries ecosystems in the Coral Triangle. These can be broadly categorized as weak governance, socioeconomic conditions, and ecosystem change.

1. Weak Governance

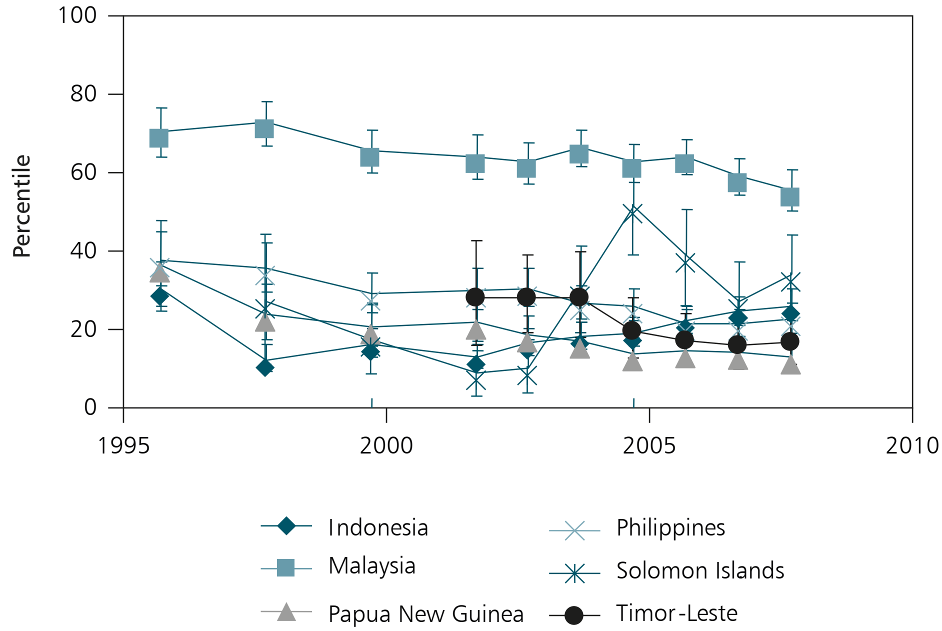
Weak governance in fisheries includes corruption, conflicts of interest, inadequate resources (physical, human, and financial) for fisheries management, poor enforcement, illegal fishing, lack of stakeholder participation or inclusion in decision making, lack of a clear vision for the fishery sector, and user conflicts.

Corruption. Demands for illegal payments for fishing licenses, permits, or access rights by politicians and public servants are probably the most pervasive and direct form of corruption in the fishery sector. Corruption also occurs when illegal fishers are coddled or when prosecution of cases is deterred (EcoGov Project 2011). Perhaps the more chronic form of corruption is that which impedes the proper allocation of resources to target beneficiaries such as infrastructure or social services projects that worsen poverty. Based on the World Bank's assessment of the control of corruption in the world (Kaufmann, Kraay, and Mastruzzi 2009), all CT6 countries, except Malaysia, fall below the 40th percentile of the assessed countries (Figure 33).

Lack of participation in governance and management. A centralized fisheries management approach involves little effective consultation with resource users. It is often not suited to developing countries with limited financial means and expertise to manage fisheries resources in widely dispersed fishing grounds. It has been recognized that a fishery cannot be effectively managed without the cooperation of both men and women fishers and other stakeholders in helping the laws and regulations work. To date, the involvement of local communities is improving in CT6 countries and should be encouraged further.

Poor enforcement. The inability to enforce regulations that have been centrally promulgated—with little stakeholder involvement—has been the downfall of many fisheries management schemes. In addition, poorly promulgated policies, especially in islands over a huge geographical area, such as most countries in the Coral Triangle, are poorly enforced, if not unenforced. In CT6 countries, poor enforcement manifests itself in the form of illegal fishing practices, such as the use of explosives and chemicals and fine-meshed nets, targeting of fish spawning aggregations, and intrusion of commercial fishing fleets and local boats in taboo or no-fishing zones.

Figure 33 **Control of Corruption in CT6 Countries, 1995–2008**



Source: Kaufmann, Kraay, and Mastruzzi (2009).

In some countries where small-scale fishers and traders are often among the poorest people in society, the political and judicial branches, which should render judgment on illegal fishing cases, are weak. The entire enforcement continuum should be addressed, including soft enforcement or prevention of crime, which is deemed more effective than proceeding with apprehension, prosecution, and judgment.

Weak institutional capacity. In Southeast Asia, institutional weaknesses and constraints are pervasive in the fisheries resource management sector. Legal, policy, and institutional frameworks are not crafted to suit the unique features of the fishery sector, resulting in mismatches and overlaps. Torell and Salamanca (2002) concluded that overlapping mandates, institutional confusion, and conflict have become dominant features in the administration of fisheries resources in the region.

Inadequate information. One of the greatest obstacles to decision and/or policy making in fisheries is the lack of reliable data and information about various facets of the sector. Available statistics are often highly inaccurate and minimally useful and seldom sex-disaggregated or gender-related.

2. Socioeconomic Conditions

Several socioeconomic factors constrain improved fisheries management and are the root causes of some overfishing problems in the region.

Poverty. In many areas in CT6 countries, fishers are considered the poorest of the poor (Cabral et al. 2013). Poverty arises in the coastal areas because of such factors as exclusion from development programs, limited opportunities and alternative livelihoods, behavior toward patronage of vices, and debts with compounded interest. Poverty among many fishing communities and households often leads to or reinforces unsustainable fishing practices. Pulling fishing households out of poverty is constrained by few livelihood options and by high population growth rates in coastal communities. Many rural communities have low priority in national economic development planning, and have been left behind as economic development progressed in other parts of the country. Rural fishing communities generally have a higher percentage of people living below the poverty line than the national average (Whittingham, Campbell, and Townsley 2003), which is the case in the CT6 countries (Foale et al. 2013).

Other factors contributing to the poverty of these rural fishing villages include high population growth, limited access to land, economic and political marginalization, unsustainable land use practices and development, competition and conflicts over resources, health burdens, and civil strife. These rural fishing communities become even more vulnerable as resource conditions change and decline. Overfishing has reduced the contribution of fisheries to employment, export revenue, food security, and rural social stability. Furthermore, as a result of people's activities that contribute to mangrove removal, siltation, and pollution, essential coastal fish habitats are degraded, resulting in less productive fisheries.

Globalization of trade and market access. The globalization of trade creates both opportunities and risks for fishers. In some cases, it puts decision making beyond the fisher and those involved in fishing activities. The market both provides for and restricts livelihood opportunities for small-scale fishers and traders. Constraints to market access include weak bargaining power and poor marketing strategies, monopolies among wholesalers, poor product-holding infrastructure, difficulties in meeting quality standards, and lack of market information.

Technological advances. Technological changes, such as the introduction of motorization and monofilament nets, have enabled fishers to exploit nearshore and offshore fisheries resources more intensively than was ever imagined a few decades ago. These technological advances have led to increased conflicts and overexploitation of some fisheries.

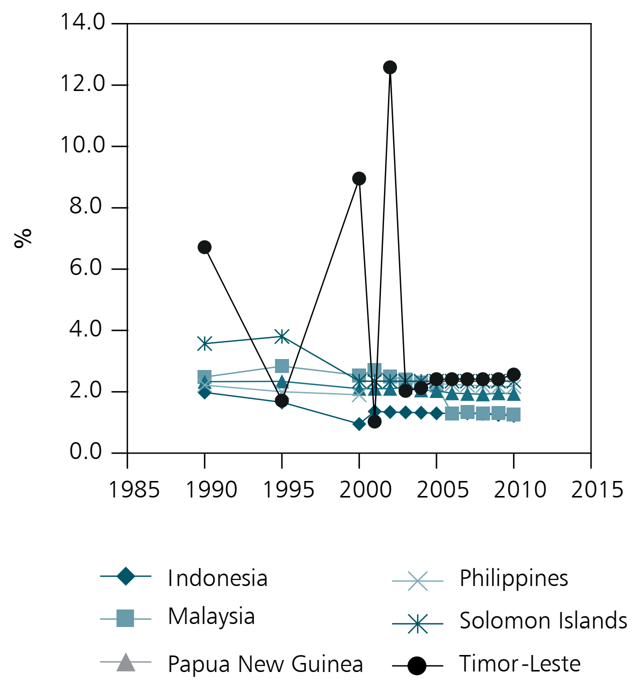
Overcapacity of fishing fleets. In many developing countries, small-scale fisheries are systematically overfished because of high levels of overcapacity. As an example, the potential yield of the highly traded grouper species from reefs in moderate condition is approximately 0.4 tons (t)/square kilometer (km^2) (Sadovy et al. 2003). Current estimates of average grouper yield reach 2 t/km^2 (Muldoon, Cola, and Pet-Oede 2009). Individual studies in Taytay and Quezon municipalities in Palawan Province in the Philippines, which provides over half of the supply of live reef fish in the country, indicate growth overfishing, as shown by the targeting of juveniles for fattening in cages before they are sold in the live fish trade. At the regional level, bigeye tuna is already considered as overfished in the entire Western and Central Pacific Ocean, while growth overfishing of yellowfin tuna is a regional concern because of the extensive harvesting of juvenile stocks in Indonesia and the Philippines (Harley et al. 2011).

Population growth. Coastal populations will continually increase and demand for resources will rise in the coming years, while coastal ecosystem functions and services continue to diminish (Burke et al. 2012). Human population growth rates in CT6 countries have been stable in the last 5 years (Figure 34). Given the combined population of the CT6 countries in 2011 of around 373 million (Table 46) and considering a constant rate of population increase, it is projected to reach 600 million by 2050. As is common among poor rural populations, the fishers' socioeconomic setting is usually conducive to high fertility. Rapid population growth, including both intrinsic population growth and immigration to coastal areas, contributes to the increasing overexploitation of natural resources and degradation of the local environment.

Political and economic marginalization. Small-scale fisheries have been systematically ignored and marginalized over the years. In most cases, this was not deliberate but a result of an accumulation of policies and development decisions to "modernize" fisheries. Many rural coastal communities behind progress in other parts of the country are experiencing increasing economic marginalization. In part, the problem is related to the low priority of rural fishing communities in national economic development planning.

Gender inequality. There is also significant gender differentiation in how fisheries resources are utilized and perceived. Failure to fully understand gender roles, inequalities, and perspectives has confounded many well-intended fisheries development and conservation initiatives. In general, gender issues on fisheries include (i) gender division of labor and income; (ii) gendered access to decision making (representation and advocacy); (iii) gender-based rights to natural and other resources; and (iv) gender-based access to markets, market information, trade, and livelihood.

Figure 34 **Population Growth Rates in CT6 Countries, 1990–2010**



Source: ADB (2011).

3. Ecosystem Change

Unsustainable fishing practices result in direct changes in the structure and composition of aquatic and marine ecosystems, changes that make them less resilient and able to produce food for millions of people in the Coral Triangle. However, indirect people's activities also affect the biodiversity and productivity of fisheries ecosystems. These include pollution from land-based sources, and habitat degradation and destruction (Burke et al. 2012). From a longer-term perspective, anthropogenic climate change is expected to have significant impacts as well. With increasing pressure on aquaculture production to supply local and export fish demand, various forms of ecosystem threats exist—from continued conversion of mangrove ecosystems to growth overfishing for juvenile live reef fish.

Habitat loss, degradation, and pollution. Coastal ecosystems (coral reefs, mangroves, seagrass, and wetlands), on which many fish species depend for at least part of their life cycle, are degraded. The ecosystems are increasingly threatened by human activities ranging from coastal development and destructive fishing practices to overexploitation of resources, marine pollution, runoff from inland deforestation and farming, mining, and oil exploration. Model projections from the Reefs at Risk report (Burke et al. 2012) suggested that almost all of the coral reefs of the Coral Triangle will be extremely threatened by coupled anthropogenic and climatic stressors.

Coastal and aquaculture development. The rapid transformation of the coastal areas is mainly because of the fast pace of coastal development in foreshore areas, particularly for tourism and business enterprise development, housing, and aquaculture. These have resulted in massive conversions of mangrove ecosystems, reduction of arable land for fisher and/or farming families, and increased inflow of nutrients from household wastes and aquaculture feeds.

Climate change. One likely result of climate change is worsening pressure on marine fish stocks resulting from extreme or erratic rainfall; and increasing sea surface temperatures, ocean acidification, sea level, and storminess. Small-scale fishers, who often lack mobility and alternatives and are often the most dependent on specific fisheries, will suffer disproportionately from such changes (Sadovy 2005, McClanahan et al. 2008).

Illegal, unreported, and unregulated fishing. A major source of economic leakage occurring both in the high seas and coastal waters is illegal, unreported, and unregulated (IUU) fishing. It is also considered as a confluence of several drivers—weak enforcement, governance failure, corruption, and weak institutions—resulting in economic losses as measured through opportunity costs, faster pace of resource degradation, and unequal resource distribution. In developing countries, illegal fishing by large-scale vessels, including distant water fleets, is widespread. In the Arafura Sea of Indonesia, for example, the annual average total loss due to IUU fishing reaches 1.3 million t valued at Rp11.4 trillion (Box 1). Such boats often come into conflict with small-scale fishers by encroaching on inshore waters, increasing competition for the resources, and leaving such areas depleted and habitats degraded.

Accurate production from IUU fishing is difficult to determine because, by its very nature, IUU operations are not well documented. Nevertheless, some studies estimated that the worldwide annual production from IUU operations could range from 11 million t to

Box 1. Summary of a Study of Illegal, Unreported, and Unregulated Fishing in the Arafura Sea, Indonesia

"The ultimate deterrence to stop fishers engaging in IUU practices is if they have no markets to sell their catch to."

Fish catch that is not reported (unrecorded) is one of the components of illegal, unreported, and unregulated (IUU) fishing activities, which have become a major international issue in the past decade. Fisheries resources in the Arafura Sea Fisheries Management Area have been intensively exploited by industrial-scale fishing fleets using fish trawls, shrimp trawls, and bottom longlines.

Based on recorded data, interviews, and a series of workshops and consultations, this study attempts to estimate IUU in this region using the "anchor points and influence table" approach and an estimation of uncertainty using Monte Carlo simulations. Unrecorded catch is divided into (i) catch that is thrown away (bycatch, discards), (ii) catch that is not reported, (iii) catch that is reported but not recorded or is improperly recorded (misreported), and (iv) illegal fishing activities. In the early stages of shrimp exploitation, bycatch was relatively high but there has been an increasingly downward trend (about 50%) in bycatch in this fishery during 2000–2005.

Bycatch from the capture of finfish using fishnet and bottom long lines can be considered negligible as hardly any fish is discarded. The highest level of misreported catch (95%) occurs in the bottom longline fishery, followed by the fishnet fishery, and the least in the shrimp trawl fishery. The highest level of illegal catch (average of 35%) occurs in the fishnet fishery, where fishes are directly transferred (transshipped) from the capture fishing vessel to a foreign carrier vessel for direct shipment to the country of origin of the carrier vessel. Levels of illegal catch in the shrimp trawl and bottom longline fisheries are unknown, but are assumed to be around 5%.

Assuming that the price of fish is $1 per kilogram, illegal fishing in the Arafura Sea had caused financial losses of Rp5.9 trillion/year. This figure excluded losses due to bycatches that were discarded (unregulated) and catches that were not reported (unreported). The discarded bycatches were estimated to be around Rp2.2 trillion/year, while the unreported catches amounted to Rp3.3 trillion/year. The annual average of illegal catches was estimated at 655,000 tons, of which 240,000 tons were discarded and 364,000 tons were unreported. The annual average of total loss of Indonesia due to IUU fishing in the Arafura Sea was estimated to reach 1.26 million tons.

Source: Wagey et al. (2009).

26 million t, accounting for 10%–22% of the world's total fisheries production and valued at about $10 billion–$23.5 billion per year (Agnew et al. 2009). Other earlier studies suggested similar estimates of $25 billion (Pauly et al. 2002) and $9 billion (MRAG 2005). In the Asia and Pacific region, the total estimate of production from IUU fishing could be about $5.8 billion annually (Table 48).

Literature collected shows that the IUU of reef fisheries in Raja Ampat (Indonesia) was valued at 20%–26% of total production (Varkey et al. 2010). In Papua New Guinea, 6,000 t of tuna, 6,000 t of sharks, 2,000 t of bêche-de-mer, and 11,000 t of demersal and/or coastal fishes were estimated to reach $27 million. In the Philippines, 80,000 t or $1.6 million per year from foreign fishing vessels alone were estimated (Palma and Tsamenyi 2008).

Table 48 **Selected Illegal, Unreported, and Unregulated Information in the Coral Triangle**

Site/Country	Year	Species	Volume	Value ($)
Raja Ampat, Indonesia[a]	2006	Reef fishery	20%–26% of reported catch	
Raja Ampat, Indonesia[a]	2006	Reef fish, tuna, anchovy, shark, sea cucumber, and lobster	40 t higher than reported catch (or a factor of 1.5)	40.0 million/year
Philippines[b]		All	80,000 t (by foreign vessel fishing)	1.6 million/year
Papua New Guinea[c]		See "IUU" column	6,000 t tuna, 400 t shrimps, 6,000 t sharks, 2,000 t sea cucumber, and 11,000 t demersal and/or coastal fishes	26.6 million
Indonesia[d]	2001		85% of all vessels >50 gt (~7,000 vessels) operated without license	
Arafura Sea, Indonesia[d]	1980s–1990s	All	Thai-based operators reportedly responsible for biggest loss of earnings (60%)	
Indonesia[d]	2002–2003			~2.1 billion/year
Indonesia[d]	2006			~3.0 billion
WCPO[e]		Tuna		134.0–400.0 million
Sulawesi Sea[e]				227.0 million
Indonesia/ Philippines[e]				2.0 billion
Papua New Guinea[e]				26.5 million
Indonesia[d]	2003			103.3 million
Indonesia[d]		Large pelagics	Purse seine and longline	153,604
Indonesia[d]			Cyanide	46.0 million
Philippines[d]			80,000 t	1.6 million/year

gt = gross ton; IUU = illegal, unreported, and unregulated; t = ton; WCPO = Western and Central Pacific Ocean.

Note: Prepared by Richard Muallil.

Data sources: [a] Varkey et al. (2010), [b] Palma and Tsamenyi (2008), [c] MRAG (2005), [d] Budy et al.(2009), [e] Lack (n.d.). .

C. Management Approaches toward Assuring Fisheries Ecosystem Sustainability

Given the diversity of fisheries in the Coral Triangle, a myriad of tools and strategies are being implemented to help manage fisheries and sustain fish production. Most of these management strategies focus on regulating fishing effort and catches to help ensure sustained fish production. The FAO categorizes management strategies targeting fishing effort as "input controls" and those targeting catches as "output controls" (Cochrane and Garcia 2009).

1. Fisheries Management Tools and Strategies in the Coral Triangle

Fisheries management in the Coral Triangle employs both input and output controls and some conservation measures, which can be classified under the ecosystem approach to fisheries management (EAFM).[73] Input controls are more commonly employed in CT6 countries than regulations on catch rates and catch volumes (Table 49). Limits on fishing grounds through zoning, establishment of fish sanctuaries or fishing exclusion zones, protection of critical fish habitats, and spawning aggregation sites are implemented but at varying degrees of enforcement. Timor-Leste established in 2007 its first marine protected area (MPA), the Nino Konis Santana Natural Park. In all CT6 countries, destructive fishing gears, such as use of dynamite and cyanide and air compressors to assist fishing, have been prohibited on a national scale.

Conservation measures are also being implemented by CT6 countries. These include seasonal closures in observance of important fish life cycle stages, fish habitat restoration strategies, restocking of fishery resources, and ban on catching some species of fish and invertebrates. Compared with input controls, however, these measures are employed more locally and vary greatly in detail across the CT6 countries.

Subsidies are implemented primarily by the Coral Triangle Southeast Asia (CT-SEA) countries. Respondents from the Coral Triangle Pacific (CT-Pacific) countries did not note the provision of subsidies in their responses although the move of PNG, Solomon Islands, and Timor-Leste to further tap their vast fishery resources might result in the application of subsidies.

Traditional fisheries management measures are more widely applied in CT-Pacific countries than in CT-SEA countries. Sacred areas serve as de facto protected areas for fishing that are embedded well within the culture of local communities. The CT-SEA countries could learn from their Pacific counterparts in these types of management interventions.

Output controls are least employed by CT6 countries. The multispecies, multigear fisheries, and the presence of significant numbers of small-scale and subsistence fishers, make the implementation of catch quotas very difficult in CT6 countries. In some countries, employing fish size restrictions is being started for some species, although information for most species on the local values of "length at maturity" limits its application. This is, however, a promising

[73] To obtain information on management tools and strategies, a form was disseminated to fisheries officials and staff, fisheries managers, researchers, and experts in CT6 countries with a request that they identify existing fisheries management tools and strategies implemented in their respective countries.

Table 49 **Fisheries Management Tools and Strategies Implemented by CT6 Countries**

Management Tool	Indonesia	Malaysia	Papua New Guinea	Philippines	Solomon Islands	Timor-Leste
Input Controls (Effort)						
Ban on some gears	✓	✓	✓	✓	✓	
Compressor ban			✓	Local	✓	
Cyanide use ban	✓	✓	✓	✓	✓	✓
Dynamite use ban	✓	✓	✓	✓	✓	✓
Limits on number of fishing vessels or boats		✓	✓		✓	
Limit on hours or days for fishing			✓		✓	
Technology limits (e.g., prohibition on use of fish finder, high-powered lights, etc.)			✓	✓	✓	
Boat size limits	✓	✓	✓	✓		
Engine horsepower limits		✓				
Limit on the number of fishers		✓		Some areas		
Licenses or permits	✓	✓	✓	✓	✓	
Surveillance efforts on fishing activities	✓	✓	✓	✓	✓	
Ban on use of multiple gears per boat	✓					
Protection of critical fish habitats	✓	✓	✓	✓	✓	✓
No fishing in spawning aggregation areas	✓	✓	✓	✓	✓	
Zoning or allocation of fishing areas	✓	✓	✓	✓	✓	
Output Controls (Catch)						
Catch quotas or total allowable catch			✓		✓	
Fish size limits			✓	Local/species	✓	
Limiting bycatch and discards	Turtle		Tuna, turtle	Tuna, turtle, dolphins	Tuna, turtle	
Conservation Measures						
Seasonal closures and/or fishing bans related to reproduction of fishes or migration runs	✓	✓	✓	✓	✓	

continued on next page

Table 49 *continued*

Management Tool	Indonesia	Malaysia	Papua New Guinea	Philippines	Solomon Islands	Timor-Leste
Fish habitat restoration	✓	✓	✓	✓	✓	
Stock enhancement and restocking	✓	✓	✓	✓	✓	
Ban on species (e.g., napoleon wrasses, turtles)	✓	✓	✓	✓	✓	
Subsidies Financial subsidies provided by governments (e.g., free gears or boats, discounted gas prices, tax cuts, etc.)	✓	✓				
Gear buy-back		✓				
Traditional fisheries management (e.g., sacred areas)	✓	✓	✓	✓	✓	

Source: Based on a survey conducted under the ADB technical assistance, Regional Cooperation on Knowledge Management, Policy, and Institutional Support to the Coral Triangle Initiative Project.

approach that can prove to be especially useful in areas experiencing high levels of exploitation at critical stages in the life history of certain fish species.

There is no single, simple solution to the problems in fisheries management. The complexities of fisheries in the Coral Triangle region make the use of a single approach ineffective. Given these realities, the only feasible solution may be one that is based on a coordinated and integrated approach involving resource management, resource restoration and conservation, livelihoods, economic and community development, and restructured governance arrangements. This implies an increased focus on people-related solutions and on communities.

This approach recognizes that solutions involve targeting not just the individual fisher but also the whole household and the broader economic livelihood strategies. To be effective, solutions must address not only resource and technical issues but also the underlying nonresource-related issues of poverty, vulnerability, and marginalization of coastal households and communities. The strategy needs to address multiple challenges, including food security, jobs, income generation, livelihoods, health, improved quality of life, social development and community services, and infrastructure.

This approach also finds solutions in the fishery sector and non-fishery economic sectors, calling for a broader vision of the fisheries system as a whole—one that goes beyond fisheries sector-specific policies to a vast array of seemingly unrelated policies that may have beneficial side effects for the fishery sector. The broader policy context is justified by the understanding and development of linkages among fisheries resources management, social and community development, coastal community economies, and regional and national economies. Departments or agencies of fisheries cannot undertake this approach alone. It is necessary to reach out and coordinate with other government ministries or departments with expertise in economic and social development, for example; and across different levels of government, from national to local.

Five key strategies are put forward, among the many strategies to address the vulnerabilities of coastal fishing communities: (i) rights-based management, (ii) livelihood approach, (iii) social marketing, (iv) resource restoration, and (v) governance.

2. Rights-Based Resource Management

Many fisheries in CT6 countries are being managed sustainably using traditional management systems. These include community knowledge of fish spawning aggregations and the need to protect those areas, various forms of access restrictions, and spatial and temporal fishing seasonality. Temporarily closed areas or fishing taboos for replenishing stocks, spiritual reasons, or rights allocation have long been practiced in the Pacific (Cohen and Foale 2011). Timor-Leste also has a traditional law to restrict access to local resources known as *Tara Bandu*.

There are various forms of rights-based strategies where management duties are usually anchored on the community. One form is the property rights-based approach, where a community may have access to defined geographic resources. Rights-based arrangement in this case is usually effective for less mobile species (e.g., sea ranching of sea cucumbers and shells). Some CT6 countries use the property rights-based approach both for less mobile and highly mobile species.

In the Philippines, exclusive rights for the access of fisheries at the municipal level are being implemented in some areas (e.g., Calatagan, Batangas). By doing so, the local government unit has sole responsibility for maintaining the sustainability of the fish stocks. In times when there are surplus stocks, some municipalities allow commercial boats from other towns to fish in their areas in exchange for an access fee (e.g., Lubang, Occidental Mindoro). In Malaysia, fishing grounds are compartmentalized, and fishers are assigned to fish only in specific fishing grounds. In Pacific island countries, traditional laws, such as fishing taboos, provide regulation for exclusive access rights to resources. For communities dependent on highly mobile species (e.g., small pelagic fish), large-scale strategies that are collaborative rights-based, and not merely property rights-based, are necessary.

Resources management must be innovative and utilize a mix of management measures. Difficult decisions will need to be made on the use and impacts of fishing rights and access control measures, as there will be positive and negative social and economic implications. Preferential access rights can be assigned to coastal areas for small-scale fishers through fish zones, for example. Given their characteristics, small-scale fisheries are well suited to community property rights systems.

Group fishing and territorial use rights for fishing hold promise for restructuring the resource into a regulated common property. A group of fishers can determine who has access to the area and how to harvest fish from there. For implementation to be successful in small-scale fisheries, any of these measures must be simple and cost-effective because of the limited resources for administration and enforcement. For example, all boats that are allowed access to a particular fishery may be painted the same color with the license number prominently displayed.

In addition, resources management may involve the use of more conventional fisheries management measures such as limits on gear, fishing time, and season. Gear restrictions may be used to limit the types of fishing gear, or fishers may be allowed alternate days or areas to fish. Fishers may still be allowed to fish, but certain fishing practices or gears, which contribute to overfishing or overcapacity, may be forbidden. This should be undertaken through a gradual process over time to reduce negative impacts. In all cases, effective monitoring, control, and surveillance measures will be needed.

While access control may seem simple at first, the complexity of small-scale fisheries makes implementation difficult. One of the biggest issues is that of entitlement, and the question is, who is entitled to have access to the fishery? This question will need to be addressed initially and is best accomplished through participation of, and negotiations with, individuals and groups to ensure equity. For any small-scale fishery, there are a multitude of users from various backgrounds and needs. There are full-time fishers and part-time fishers using various fishing gears. There are seasonal fishers (such as upland farmers and migratory fishers) and there are subsistence fishers (such as widowed women). For example, restricting the access of an upland farmer, whose family's livelihood strategy is based on having access to fish for food during lean periods, will affect its food security. These entitlements are often informal and based on tradition and indigenous rights. These individuals may not be able to argue their rights to the resources in a legal framework. However, a structure should be established to allow all who believe that they are stakeholders and have the right to argue their case for entitlement. In essence, access to fisheries should consider the level of dependency and poverty conditions of the different resource users in a fisheries management area.

3. Livelihood Approach to Fisheries Management

The livelihood approach focuses on what the community has, rather than experimenting on other interventions that are not complementary with the expertise and culture of the community (Allison and Ellis 2001). The approach focuses on enhancing the resources and capacity of the fishing communities with a view to addressing the fishers' needs, their dependents, and the broader community. The approach recognizes the diversified livelihood nature of many of the fishing communities as an adaptation strategy for variable and cyclical fish stocks. More emphasis should be given to enhancing the benefits derived from alternative livelihoods rather than "professionalizing" the act of fishing (Allison and Ellis 2001), which, in most cases, can result in increased pressure on fisheries rather than a desired reduction in fishing pressure.

While heavily advocated as a solution to the many problems facing small-scale fisheries, the provision of supplemental and alternative livelihoods has had only limited success in most cases (Pollnac et al. 2001). The reason is that most rural economies only have a limited number of employment opportunities available. In most cases, excess labor already exists in these rural economies. A resource, like land, is not readily available or is too costly to purchase. Credit is difficult to obtain, and skills training for finding other jobs is not readily available, if at all. The rural economy may have weak links to the regional and national economy and is not growing enough to absorb the growing rural labor force.

In such cases, it will be necessary to understand regional and national economic development trends, projections, and policies to determine future employment, investment opportunities, and constraints. Working with economic development experts, and analyses of trends and projections in the regional and national economies and in future occupational demands, can provide directions for skills training and microenterprise development. Economic studies can provide information useful for identifying economic linkages between the community economy and the regional and national economies.

It is necessary to give fishers and their families a broad range of livelihood options, both supplemental and alternative, to choose from to support their exit from fishery; and reduce the household's economic dependence on fishery (Muallil et al. 2011). Families tend to have certain household needs. Using a household livelihood strategy, instead of solely focusing on the individual fisher, broadens the range of livelihood options. A focus on all members of the family allows them to receive training in new livelihoods to better address the income and other needs of the household. This will allow the establishment of management measures that will reduce overall fishing effort or restrict access to fishery with less economic disruption to the household. It will be necessary to go beyond the commonly used solution of giving fishers "pigs and chickens" as a supplemental livelihood to more innovative livelihood approaches involving microenterprise development, skills development and training, and use of information technology.

There is also a need to improve basic public services provided to coastal households and communities. Social and community development work can help expand opportunities in communities by integrating population, health, education, welfare, and infrastructure (e.g., roads, communication, and water) programs into the approach; thus, enhancing the social and economic adaptive capacity of the communities. Education, extension, and skills training can support supplemental and alternative livelihood programs. A formal social security mechanism can help to make fishers and their families feel more secure about change, and more willing to transition into a new fishing management strategy or livelihood. In addition, food security of the households is directly related to the education of women in households, and investing in education and health can improve nutrition in coastal communities.

The livelihood approach recognizes that policies reducing the number of fishers in small-scale fisheries without creating non-fishery employment opportunities will inevitably fail. Fishers will merely fish illegally, obtain new boats and gears, or do whatever is necessary to continue to make a living to feed their families. Another application of this approach is when local governments establish business enterprises as support for local communities. Considering the lack of capacity of the local fishing communities, poor coastal fishing communities are marginalized further instead of being released from poverty. Such situations lead to rent-seeking behavior of local capitalists, and the end result resembles a shift from public to private ownership (Cabral and Aliño 2011). The lack of regulation can also result in a monopoly in coastal commons. For example, in the live reef fish trade, traders are also "cagers." Much of the value is retained by the traders and cagers, while fishers especially those who are not cagers (for those with no start-up capital), will gain income lesser than the amount required for them to rise above the poverty threshold—and far less than what cagers earn.

4. Social Marketing and Social Enterprises

Social marketing toward conservation, maintenance of habitat quality, and sustainable use of resources at various governance levels will be important in maintaining the integrity and ecosystem services of the resources in the coming years. Social marketing will promote the roles of people in maintaining and improving the ecosystems in an overall sustainability framework. However, marketing of management ideas and behavioral change have innate difficulties. Selling and marketing the idea is easy for tangible products where their utility is demonstrated easily over time, and improvements and utility can be observed. Social marketing challenges include selling management or social issues that have not happened, against the better judgment of the resource users. User perceptions usually follow the concept embedded in the "tragedy of the commons" that "if they will not harvest it now, others will" (Hardin 1968).

Social enterprise, as opposed to business enterprise, is an act of doing business with social goals. Social marketing, together with governance and incentives, is a crucial ingredient for social enterprises. In a social enterprise, premiums are imposed on selling goods and services that conform to good practices based on environmental standards. These standards are for the social and environmental good, but there is an innate challenge of selling the idea to consumers, aside from the premium cost imposed for following high-quality environmental and social standards.

The link of fishing to social enterprises (e.g., value adding in the market chain and application to allow incentives toward social transformation and sustainable development) is one of the major challenges and opportunities in the Coral Triangle as is cognizance of the difference between social enterprise and purely market-based enterprise. Within the context of social enterprise, sustainable financing engages marginalized subsistence fishers and helps empower them. Good governance measures are crucial. Social marketing could provide transformational opportunities that empower fisher stakeholders and provide them with enabling mechanisms through innovative ordinances (e.g., conditional cash transfer programs; market, credit, and benefit sharing arrangements in fisher federations; sea ranching access; and rights-based arrangements for peoples' organizations) (Juinio-Meñez et al. 2007, Juinio-Meñez 2008) and other premiums for environmental management.

Establishing eco-businesses in coastal resources (such as payment for environmental services) must consider social and economic impediments and include barrier removal mechanisms. It is also necessary to identify barriers in governance measures to allow for fair and environment-oriented actions (Fabinyi 2012). How can social change foster positive behavioral change within a community that benefits overall society? One example is the setting up of incentives to encourage fishers to become stewards of marine sanctuaries (EcoGov Project 2011). Poor fishers can be targeted as priority beneficiaries for conditional cash transfer programs. Capacity-building opportunities could also be used to complement government and fisher engagement.

In theory, social enterprises should allow for an explicit plowback of funds or "ring fencing" for environmental management and additional benefits for people in the production side. These enterprises should also consider fairness, allocation of benefits, and costs as guiding principles within their cultural values; and integrate these to achieve sustainable development. While the primary objective of a social enterprise is to earn profits, part of it has to be aligned toward social welfare objectives, together with maintaining the integrity and sustainability of social and ecological systems.

Social marketing linkages provide the important principles of engaging fishers in the discussion, especially when setting up eco-enterprises targeting vulnerable fishers (e.g., to climate change and other stressors, such as coastal development, that may result in marginalization of fishing communities) (Allison et al. 2009). Social marketing is critical in developing the social perspective of business entrepreneurs with the environmental perspective of cultural sensitivity, scientific learning, ecological ethos of adaptive management through learning by doing, and transdisciplinary stakeholder engagement with good business sense and social responsibility.

5. Resource Restoration and Conservation

Marine protected areas (MPAs) can protect target species from exploitation and allow their populations to recover by closing an area or a population of species in an area from exploitation. Perhaps more important, MPAs can protect entire ecosystems by conserving multiple species and critical habitats, such as spawning areas and nursery beds. Stocks inside these areas can serve as a "bank account" or insurance against population fluctuations and depletions outside the protected area as a result of mismanagement or natural variability.

MPAs can also reduce conflicts between fishers and other users by providing areas where non-fishery users can pursue nonconsumptive uses of the resource. In addition to closing areas through MPAs, there is a need to restore marine habitats (coral reefs, mangroves, seagrass, and wetlands) that are susceptible to pollution and physical destruction. The restoration of these habitats, particularly those that limit the abundance of a resource at some life history stage, may be the most important step for increasing fish stock productivity. However, precautionary measures should be employed in restoration efforts, such that species used are consistent with the species that previously inhabited the area.

6. Governance

The active participation of people in this approach, through a strategy of comanagement, is mandatory in planning, formulating, and implementing development and management activities. Building and strengthening fisher organizations allow consultation, cooperation, and seeking consensus on strategies to address overcapacity. Community-based comanagement can provide a framework for such a coordinated and integrated approach. Empowered and organized people are more able to plan and engage in often complex discussions and planning needed to realize this approach. Community-based comanagement can serve as a mechanism not only for resources management, but also for social, community, and economic development by promoting people to actively learn, solve problems, address needs in their community, and adapt to change. Organized people are better able to network and provide a base for cohesive and efficient or economical actions.

There is a growing recognition of the critical role of local governments in achieving the goals and targets of the CTI. This is consistent with the guiding principles espoused in the regional plan of action (RPOA) that the CTI "should be inclusive and engage multiple stakeholders including local governments," among others. The CTI began recognizing the value of local government participation at the seventh Senior Officials Meeting (SOM 7) held in October 2011. The value of the CTI was also acknowledged at the Mayors' Round Table conducted in Wakatobi, Indonesia, and at SOM 8 in November 2012. The CTI Local Governance Network is another expression of this acknowledgment.

Increasingly, local governments have jurisdiction over management of the coastal and marine resources in the Coral Triangle, and those communities most dependent on these; and, therefore, the most vulnerable to the degradation and loss of these resources. This makes local governments in the region integral to successfully managing and reducing the threats (and their causes) posed by both human activities and natural hazards (such as climate change impacts) on these resources and the communities who depend on them.

Decentralization has been at the heart of the increased authority and responsibility of local governments in the region. In the early 1990s, there was a movement in Asia toward decentralization. This refers to the systematic and rational dispersal of power, authority, and responsibility from the central government to local institutions, to states or provinces in the case of federal countries, and to regional and local governments or even to community associations. While decentralization addressed general government administrative restructuring, it was also undertaken to support government policies and programs that stressed the need for greater resource-user participation and the development of local organizations to handle some aspects of fisheries management (Table 50).

For example, the Philippine Local Government Code of 1991 calls for the decentralization of government functions and operations to local government units; and includes specific provisions that address fisheries, such as defining municipal waters and supporting resource user rights. In Indonesia, the ratification of Law No. 22/1999 by the regional authorities in early 2001 provided the mandate for local governments to exercise responsibility over their natural resources. The local authorities can now work closely with their stakeholders in formulating policies for the management of natural resources. The law gives authority at the *kabupaten* (district) and *kota* (city) for the exploration, exploitation, conservation, and management of marine resources within 4 nautical miles of the province's jurisdiction.

The CT6 countries have taken different approaches to decentralization, as can be seen in Table 50. Except for Timor-Leste, local governments at some levels have the mandate for coastal resources and fisheries management planning, and for enacting and enforcing laws. However, most have limited budgets and are largely dependent financially on the national government. In Indonesia, PNG, the Philippines, and Solomon Islands, laws support community-based management. In PNG and Solomon Islands, significant progress in the practice of community-based management over coastal and marine resources has been achieved over the past few decades, building on a rich heritage of traditional knowledge and ancient customary practices. There is at least one form of local government association (LGA) in each of the CT6 countries, except Timor-Leste. LGAs, whether formal or informal, generally promote capacity building, advocacy, or information exchange among members. LGA membership in Indonesia and the Philippines is quite extensive. In Solomon Islands, local governments are not formally organized, but there is a mechanism (annual Premier's conference) for bringing them together on a regular basis. In Malaysia, both the federal government and the State Government of Sabah have stressed the need for more community involvement in fisheries management and establishment of community-based comanagement initiatives while still favoring strong central control of fisheries management.

The important role of local government in supporting coastal and fisheries resources management and people's participation in management can only increase in the future. Local government can provide various technical and financial services; and assistance to support local resources

Table 50 Role of Local Governments in Fisheries Management across CT6 Countries

Country/ Local Government	Role of Local Governments in Fisheries Management	Controlling Policy
Indonesia: 33 provinces, 1 special capital region, 399 districts or regencies, and 98 cities or municipalities	Municipal and/or district and provincial governments have management authority over as much as 4 and 12 nautical miles, respectively, from the shoreline of its territorial sea jurisdiction. These local governments are authorized to carry out the following: (i) exploration, exploitation, conservation, and management of sea resources; (ii) administrative regulation; (iii) zoning regulation; (iv) law enforcement of the regulation established by the regions or delegated by the central government; (v) participation in the maintenance of security; and (vi) participation in defending the state sovereignty.[a]	Autonomy Law (1999; amended 2004); Law on Coastal Zone Management and Small Islands (2007); Law 31/2004 on Fisheries
Malaysia: 13 states (including Sabah and Sarawak), and 3 federal territories	None.	Fisheries Act of 1985 (as amended in 1993)
Papua New Guinea: 20 provinces, 89 districts, 286 rural local level governments (LLGs), and 26 urban LLGs	Pass and enforce ordinances for the management of fishing and fisheries and local environment provided that these do not contravene with any of the provisions of the Fisheries Management Act.[b] These local governments are also given the general responsibility to draw up development plans for consideration by the national government. The authority, mandate, and resources for matters pertaining to fisheries and fishing activities remain with the National Fisheries Authority.	Organic Law on Provincial Governments and Local Level Governments of 1998;[c] Fisheries Management Act (1988)
Philippines: 81 provinces, 138 cities, and 1,493 municipalities	Enact appropriate local ordinances for these purposes and enforce all fishery laws and regulations within the municipal waters (defined to be within 15 kilometers from the farthest offshore island).[d]	Philippine Fisheries Code (1998); Local Government Code (1991)
Solomon Islands: 9 provinces and 1 capital city	The provincial assembly to legislate on matters, such as cultural and environment; agriculture and fishing particularly with respect to protection, improvement, and maintenance of freshwater and reef fisheries; control and use of river waters, pollution of water, and provision of water supplies; land and land uses like codification and amendment of existing customary law about land, and registration of customary rights on land including customary fishing rights.[e] Under the Fisheries Act of 1998, each provincial government is mandated to prepare and keep under review a plan for the management and development of fisheries in its provincial waters[f] other than fisheries of highly migratory species.[g]	Fisheries Act (1998)[g] (2009, amendment); Provincial Government Act of 1977

continued on next page

Table 50 *continued*

Country/ Local Government	Role of Local Governments in Fisheries Management	Controlling Policy
Timor-Leste: 13 districts and 67 subdistricts	None.	Fisheries Decree (2004)

[a] Act 32/2004, Decentralization Law of Indonesia.

[b] Sections 42 and 44, No. 29/1998, Organic Law on Provincial Governments and Local Level Governments of Papua New Guinea.

[c] No. 29/1998, Organic Law on Provincial Governments and Local Level Governments of Papua New Guinea.

[d] Section 16, Republic Act No. 8550/1998, The Philippine Fisheries Code.

[e] Schedules 3 and 4, Act No. 7/1997, Provincial Government Act of Solomon Islands.

[f] The provincial waters pertain to 3 nautical miles extending seaward from the low water line of each island in the province. If the island is situated on an atoll or has a fringing reef, the provincial waters shall include the atoll or between the island and the reef and shall extend seaward for 3 nautical miles from the low water line of the atoll or reef.

[g] Act No. 6/1998, Fisheries Act of Solomon Islands.

Source: United Cities and Local Governments Final Report (2011).

management arrangements, such as with the police for enforcement, conflict management, appeal mechanism, and approval of local ordinances for resources management. There are many lessons on coastal and fisheries resources management by local governments that can be learned and shared among CT6 countries. Although there are many different systems of government in operation, and not all lessons may be directly applicable to all countries, it is important to support this learning and sharing among local government officials and local people.

D. Convergence Opportunities, Synergies in Fisheries, and Coastal Resource Management through the Ecosystem Approach to Fisheries Management

FAO (2003) defines the ecosystem approach to fisheries management that

> ...strives to balance diverse societal objectives, by taking into account the knowledge and uncertainties about biotic, abiotic and human components of ecosystems and their interactions and applying an integrated approach to fisheries within ecologically meaningful boundaries.

Ecosystem approach to fisheries management (EAFM) is a component of ecosystem-based management (EBM), which primarily focuses on fisheries. EBM recognizes the complexity and connections of marine and coastal ecosystems, interactions with people, and the need for intersector governance. Its scale, scope, and need to consider holistic integration of various fisheries drivers (ecological and socioeconomic) make it different from traditional fisheries management approaches, which generally focus on managing single species resources, narrow

Box 2 **Definitions**

Ecosystem-based management. A management framework that integrates biological, social, and economic factors into a comprehensive strategy aimed at protecting and enhancing sustainability, diversity, and productivity of natural resources. Ecosystem-based management emphasizes the protection of ecosystem structure, functioning, and key processes; and is place-based in focusing on a specific ecosystem and the range of activities affecting it. It explicitly accounts for the interconnectedness among systems, such as air, land, and sea; and integrates ecological, social, economic, and institutional perspectives, recognizing their strong interdependences (COMPASS Scientific Consensus Statement).

Ecosystem approach to fisheries management. This approach strives to balance diverse societal objectives by taking into account the knowledge and uncertainties about biotic, abiotic, and human components of ecosystems and their interactions; and by applying an integrated approach to fisheries within ecologically meaningful boundaries.

Ecosystem-based fisheries management. Considered to be a component of ecosystem-based management, this is focused on a single sector. Ecosystem-based fisheries management considers both the impacts of the environment on fisheries health and productivity and the impacts that fishing has on all aspects of the marine ecosystem.

Integrated coastal management. A continuous and dynamic process by which decisions are taken for the sustainable use, development, and protection of coastal and marine areas and resources.

Source: Pomeroy et al. (2013).

and specific issues, or a single ecosystem function and service (White, Courtney, and Salamanca 2002, Pikitch et al. 2004).

EAFM can involve scaling-up or scaling-down efforts depending on the ecosystem in question. In the CTI setting, many sector-specific management interventions are already in place, and the process of integrating or scaling-up these efforts remains a challenge. Consistent with the principles of integrated coastal management (Chua et al. 2006), scaling-up in EAFM can be categorized in three broad contexts: (i) geographical expansion, (ii) functional expansion, and (iii) temporal expansion (Pomeroy et al. 2013). Geographical expansion can involve integrating management from town or *barangay*-based to baywide, municipality, or networks of towns or expansion from protecting a single marine habitat (e.g., coral reefs) to considering other important habitats, such as seagrass beds and mangrove forests. Functional expansion can be in the form of a livelihood approach that explores the properties of networks of families and communities, while temporal expansion extends beyond a regular monitoring process to the consideration of future scenarios of climate impacts.

EAFM builds on what is already available in the community, yet its multiscale and multidimensional nature involves additional coordination, collaboration, integration, and synchronization of functions at various governance sectors and levels, in addition to considering a broader ecosystem of fisheries management (Pomeroy et al. 2013).

The effective application of EAFM is one of the five goals of the CTI (2009). EAFM is the preferred option for CTI toward achieving sustainable livelihood and food security (Pomeroy et al. 2013). Four regional targets are specifically stated in the RPOA as follows:

Target 1: Strong legislative, policy, and regulatory frameworks are in place for achieving EAFM.

Target 2: Income, livelihoods, and food security of people are improved in coastal communities across the region through a sustainable coastal fisheries and poverty reduction initiative ("COASTFISH").

Target 3: By 2020, effective measures are in place to ensure that exploitation of shared tuna stocks is sustainable, with tuna spawning areas and juvenile growth stages adequately protected.

Target 4: A more effective management and more sustainable trade in live reef fish and reef-based ornamentals is achieved.

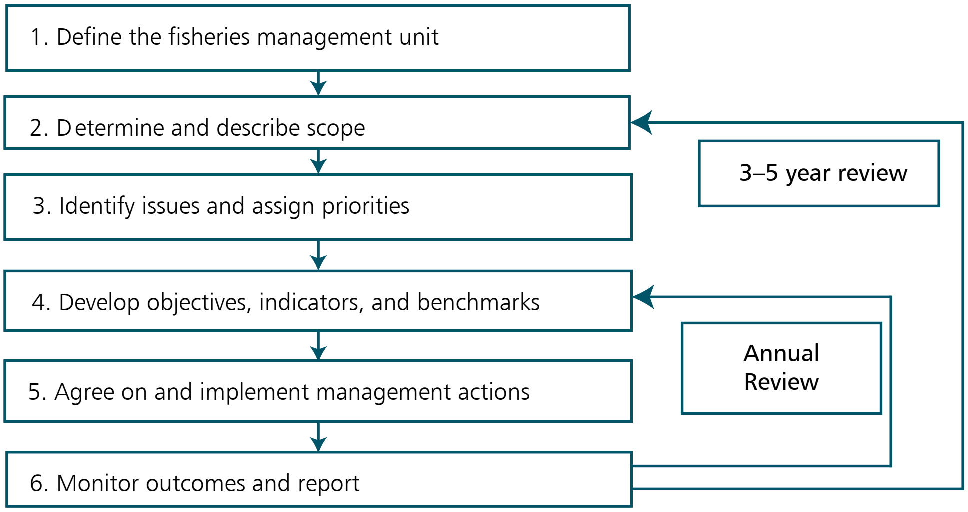
Most of the work done so far in the CTI on EAFM has focused on Target 1, which is foundational and necessary to ensure effective implementation of the other targets. For Target 2, livelihood approaches to fisheries management, which is compatible with social enterprise, territorial use rights and/or tenurial arrangements, will play a significant role. Social and economic policies are crucial to level the playing field and nurture both market (e.g., sustainability incentives through the value chain players) and nonmarket mechanisms (e.g., regulatory standards on food safety and environmental friendliness). Reducing the contradicting and rent-seeking tendencies and transactional costs at various governance levels can help improve income, livelihood, food security, and sustainability of the fisheries ecosystem.

For Target 3, tuna stock size, migratory patterns, and spawning grounds—and also climate impacts on the stocks—remain as gaps (CTI 2009). Although indicative information is available, there is a clear need to invest in monitoring and evaluation (M&E). This can be achieved by considering both geographical and temporal expansions, based on EAFM. For example, tuna is a highly migratory species with life stages spent in different areas. Understanding and identifying the location of these areas, which are necessary in assuring the connectivity and survival of the tuna stocks, are crucial for regional management. This can be facilitated by CTI's regional sharing forums (CTI 2009).

The need for developing an EAFM plan and its implementation, and also M&E guidelines, has been articulated in the EAFM guidelines for the CTI (Pomeroyet al. 2013), which are consistent with the guidelines of FAO (2003, 2009) (Figure 35) and SPC (2010). Climate-smart policies in the region, interlinked with various adaptive management measures at local and national scales, can contribute to disaster risk reduction, such as the local and regional early adaptation plans for straddling and shared stocks, which are necessary for regional strategic action plans.

The RPOA under EAFM states that by 2013, there will be a 20% increase in cash income of local government and fishers from the LRF trade. The increase will be attained by harvesting fish from sustainable sources and by protecting at least 3,500 hectares (ha) of critical habitats of economically important reef fishes. The progress of work toward this goal remains to be evaluated.

Figure 35 **FAO Fisheries Management Processes and Guidelines, 2009**



FAO = Food and Agriculture Organization of the United Nations
Source: FAO (2003; 2009).

Fisheries interventions are already being carried out by individual countries at various governance levels, but many of these do not necessarily target the sources of vulnerabilities of coastal communities. The role of EAFM in aligning and coordinating the different actions and programs into a management scheme where ecosystem, socioeconomic, and governance objectives are holistically considered is an important regional challenge and opportunity. EAFM plays a significant role in strengthening complementarities through the existing regional bodies and minimizing conflicting, perverse market effects.

The context and practice of EAFM in the Coral Triangle, while acclaimed to be an important framework, especially when linked to EBM, remains to be further elucidated (Browman and Stergiou 2005, Cabral et al. 2013). Considering that the most prevalent threats to coral reef ecosystems are related to fisheries overexploitation and habitat degradation, the interrelated analyses and responses are crucial in addressing these imperatives. Implementing EAFM requires putting in place the requisite governance processes, systems, and standards. This means addressing the impediments (e.g., no functional Coral Triangle EAFM bodies), barriers (e.g., CTI-EAFM implementation agreements in incipient stage), and vulnerabilities that are presently high in most CT6 countries (Cabral et al. 2012).

Achieving the good governance objectives of EAFM in the Coral Triangle requires (i) accelerating capacity-building efforts; (ii) enhancing connectivity in the linkages of habitat conservation with social and governance drivers, especially those that lead to societal benefits of sustaining ecosystem functional resiliency (Folke et al. 2010); (iii) provisioning of goods and services (Padilla 2009); and (iv) food security (Foale et al. 2013). Processes, often less considered in the coastal commons, would need to address the allocation of access and use rights (Charles 2011).

More specifically, the enabling institutional arrangements need to be developed, transitioning and transforming from open access fisheries to rights-based or tenurial arrangement settings (e.g., permits, individual transferable quotas, sea ranching, and aquaculture arrangements); and the need to match the changes in the various archipelagic and coastal property rights and rules of law (Cabral and Aliño 2011). It is well known that clarifying access rights can address the problem of "race for fish" (World Bank 2004; Beddington, Agnew, and Clark 2007; Cunningham et al. 2009 as cited in Allison et al. 2012). This strategy is already being employed by the CT-SEA countries through contemporary tenure arrangements, and has been an integral part of the culture and tradition in the Pacific island countries through traditional marine tenure arrangements (Foale et al. 2013).

These needs are put into context to meet the challenges of increasing population demand for fisheries food, declining capture fisheries production, degradation of habitats from unregulated aquaculture activities, and unwise land use practices. Capacity building in governance, social and economic resilience, and coping with perturbations are necessary to address the urgent threats from climate change and human impacts, low effectiveness of coastal governance, hunger, and poverty (Cabral et al. 2012). To allow more inclusive development of EAFM governance, the communication of science-based choices for informed decisions and motivated actions through a range of incentives are necessary (Hilborn et al. 2005). Social marketing and social enterprises enable the tactical and strategic entries to provide value-added contributions toward more sustainable fisheries and better food accessibility. Successful systems usually involve institutional arrangements that provide incentives to individual operators that lead to behavior consistent with conservation (Hilborn, Orensanz, and Parma 2005).

The main disadvantage of social enterprise is that it is more financially costly than the usual business enterprise since a premium for social and environmental cost is imposed. The livelihood approach gives more emphasis on the roles of individuals, families, and community networks. The benefits of social enterprise can be fully realized by utilizing the "network" forged by the livelihood approach, and the "network" property of the traditional and emerging management systems. Premiums associated with social enterprise can be reduced by economies of scale in the village or in the community, for example, if coral farming is accepted by the community and recognized by the government as a viable alternative to wild harvesting in Solomon Islands.

A community, network, or fisheries association can establish support mechanisms to improve the quality of fish products and demand higher prices. In tuna fishery, the quality of fish determines the price. A fishery association with a revolving fund as a support system can provide assistance to members (e.g., for buying ice) to ensure fish quality and maximize benefits. By doing this, fishers are also released from restrictions of selling their products at low prices due to indebtedness. In the region, fair trade—rather than free trade—can be imposed if a regional policy body is present. The wholesaler controls the bottom (source) and top (retail) prices of the LRF trade. A regional management body can ensure that a sustainable supply is maintained and benefit sharing is fair.

Drivers that lead to the threats and weaknesses often identified in various workshops are related to population growth, unwise development, disconnects in governance, and ecological and socioeconomic conditions (Halpern et al. 2012; ADB, forthcoming). It is imperative to make it known within the governance structure and citizenry that the compelling reason for unity in the Coral Triangle is its highly connected resources that are in the center of global marine biodiversity. Both ecological and cultural affinities abound among the cultures of CT6 countries, which bind their past to their future development trajectories (Marsh 2012).

The EAFM within an overall archipelagic governance framework will play a significant role in resource management in the Coral Triangle. The sustainability of ecological and social systems in the Coral Triangle requires a diverse range of access, use rights, and incentive mechanisms (Charles 2011) coupled with assured safety nets to cope with future perturbations. For these strategies to be effective, the following should be undertaken:

(i) provision of good governance services by government agencies and service providers accountable to good performance standards and incentives through fair access and rights arrangements at local, national, and global arrangements;
(ii) demand for good governance through people's participation that is informed, anchored on science-based social marketing and responsible fisheries; and
(iii) community-based organizations engaged in sustainable fishery enterprises and value-adding mechanisms both through market and nonmarket incentives.

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VIII. Regional Call to Action

Annabelle C. Trinidad,[74] Rollan C. Geronimo,[75] Reniel B. Cabral,[76]
and Porfirio Aliño[77]

The suggested actions are guided by an economic framework that seeks efficiencies in the allocation of resources; accounts for private, social, and environmental costs; maximizes benefits arising from resource use for present and future generations; and recognizes the interactions of the fisheries and aquaculture sector with the rest of the economy. However, the solutions to economic issues are not necessarily economic in nature but also consider other factors, such as the linkage of the fisheries governance framework with the greater economic sector. Eight regional actions recommended range from the conduct of further research on marketing and coastal asset valuation, to capacity building in economic literacy, and to policy harmonization in the region. These regional actions are mostly delimited by the existing Coral Triangle Initiative (CTI) plans of action, although some require that the plans be revisited and possibly revised or refined.

A. Summary of Findings

Capture fisheries. The marine capture fisheries sector is the principal source of fish supply in CT6 countries and a major contributor to food production—and hence, food security—both at the regional and global levels. At least 29% or 1.9 million tons (t) of the global production of tuna, bonitos, and billfishes came from CT6 countries in 2009. The value of fisheries from coral reefs was estimated at $3 billion or 30% of total capture fisheries value in the region, and larger if tuna and associated species were included. The CT6 countries also produced 55% of the 7,753 t of global production of the International Statistical Standard Classification of Aquatic Animals and Plants (ISSCAAP) species group of "pearl, mother-of-pearl, and shell," and accounted for 80% of global harvests in corals and 90% of turtles.

The majority of fish stocks in Indonesia, Malaysia, and the Philippines are considered to be at least fully exploited; and maximum sustainable yield estimates indicate that most of the countries are nearing, if not beyond, critical thresholds for many fish stocks. Overfishing results in various types of economic inefficiencies since higher costs are incurred due to excessive use

[74] Footnotes 21, p. 43; 32, p. 85; and 54, p. 106.
[75] Footnotes 3, p. 5; 25, p. 63; and 33, p. 85.
[76] Footnotes 4, p. 5; and 73, p. 140.
[77] Footnote 74, p. 140.

of fishing effort relative to the available fish stock, and lead to diminishing private and societal profits and increasing in illegal activities.

Aquaculture. Production of aquaculture is increasing exponentially at almost 25% per annum. More than 70% of this production, including from freshwater sources, is made up of aquatic plants, while 95% of marine aquaculture production comprises aquatic plants (e.g., seaweed). Inland aquaculture has been a good source of additional fish supply, but its production is much lower than marine capture fisheries. Marine and brackishwater aquaculture has contributed minimally to fish supply since production is geared toward aquatic plants rather than on foodfish.

The history and approach to aquaculture in the Coral Triangle-Southeast Asia (CT-SEA) and CT-Pacific countries vary between these two subregions as a result of their different resource endowments, overall economic thrusts, and population pressures. Aquaculture in CT-SEA countries is expected to expand and focus on the production of high-value fish species and the export market, while the CT-Pacific countries will focus on freshwater aquaculture to feed their growing populations. The resources required to support marine aquaculture, not to mention the indirect use of trash fish as the main component of fish meal, are enormous. This could result in an increasing pace of exploitation for the species targeted for reduction into fish meal, especially when fisheries management regimes are lax.

While aquaculture is considered an important means of addressing food security issues, its negative environmental impacts must be managed accordingly. An overheated aquaculture sector characterized by overstocking, overfeeding, and excess carrying capacity results in economic losses far greater than the cost of dead fish, including the opportunity costs of capital and labor, environmental costs, and costs associated with forward and backward linkages in the supply chain.

Trade and value retention. Trade within the CT6 countries is less significant than trade between them and the global markets, owing to their similar resource endowments. Demand for fish from the CT6 countries (and other developing countries) will increase as a result of the decline in fishery resources. The CTI is the first agreement entered by all six countries in a region that already has existing multilateral coordination mechanisms and agreements on fisheries and coastal and marine resources management. The CTI is an opportunity to synchronize and integrate these various arrangements toward a more targeted management of coral reefs and fisheries in the region for improved food security and well-being of the people.

Solomon Islands still legally exports corals in the form of curio (dead) and aquarium pieces (live coral fragments). Other CTI countries, such as the Philippines, have outlawed coral exportation, but data from *United Nations Comtrade* indicate that coral exportation is still going on, with records being lumped with shells, pearls, mother-of-pearls, and others. Among the trading partners of Solomon Islands, none is more important than the United States (US), which absorbs more than 90% of coral exports. The curio coral trade has become the most significant component of the coral export trade. As opposed to aquarium corals, where coral fragments are harvested, curio markets require huge pieces of corals and sometimes entire coral colonies.

The live reef fish trade case study showed that the roles of the fisher and the cage farmer are intertwined. Fishing and cage farming earn handsome profits that allow households to easily breach the poverty threshold level. Tuna handlining and value retention at the fisher level can also result in higher profits if the product is exported and the quality is maintained. Traceability of catch and proper submission of catch records are some of the techniques to add value without necessarily adding more processing activities.

Subsistence fisheries. The undervaluation of subsistence fisheries can be significant. In Solomon Islands, for example, food goods derived from coral reefs yield an average subsistence and cash value of SI$9,600–SI$43,000 per respondent per year across four study sites, with fish being considered as the most important reef good. Based on average catch rates per day, fish consumed by households in the Philippines is at least 16% of municipal fisheries production on a yearly basis, while the value is 22% of the daily food poverty threshold of P162 ($3.95). Timor-Leste's subsistence sector, while conforming to the technology-related characteristics of subsistence fishing, is generally market-oriented. Although the case studies presented in this report confirm the significance of subsistence fisheries in the CT6 countries, it is necessary to make additional investments in data generation, preferably in collaboration with other non-fisheries agencies to provide more solid evidence of this contribution.

B. Recommendations

Based on the findings of this study, the following are the proposed regional and national actions:

(i) Finalize and implement the ecosystem approach to fisheries management (EAFM) policy framework that provides guidance on minimum common policies
- Agree on common policies that curtail excess fishing effort and curb all forms of harmful fishing practices including coastal illegal, unreported, and unregulated (IUU) fishing;
- Address economic leakages brought about by high seas IUU fishing through more efficient monitoring, control, and surveillance systems; data sharing; and full compliance with the Food and Agriculture Organization of the United Nations (FAO) International Plan of Action on IUU;
- Include within the EAFM framework the strengthening or formulation of joint action programs consistent with social and ecological connectedness; and
- Harmonize policies on trading of fisheries commodities.

(ii) Integrate aquaculture within the EAFM framework espoused in the regional plan of action (RPOA) in future iterations of the document
- Apply a harmonized standard for the harvesting, caging, and transporting of live reef fish (LRF) consistent with the EAFM approach;
- Provide economic literacy training to aquaculture operators for them to better appreciate the full economic costs of mismanagement including those imposed on the environment and the full supply chain;
- Maintain aquaculture best practices as a minimum requirement to manage aquaculture more sustainably through the full implementation of the FAO Code of Conduct for Responsible Aquaculture and agree on joint monitoring criteria;
- Promote low trophic level aquaculture commodities that require less feed and are more environment-friendly;

- Implement incentives for aquafarms that comply with good management principles and disincentives for those that thwart such principles; derive incentives from supply and/or value chain participants generating extraordinary resource rents; and design payments for ecosystem services to compensate fishers who delay harvest on juvenile species of LRF;
- Collaborate on developing technologies that will diminish the negative impacts of aquaculture on capture fisheries and the environment, such as efficient feeds that lower the feed conversion ratio; and
- Conduct research and technology improvement on coral farming across the CTI, both for trade purposes and resource enhancement.

(iii) Maximize the potential of CTI as a venue for cost-effective action through knowledge sharing and common advocacies, especially between the CT-SEA and CT-Pacific countries
- Use a phased approach, agree on output controls for species like tuna and other pelagics in coordination with other fisheries management organizations;
- Use the CTI as a forum to share lessons learned in assessing and monitoring the effectiveness of various fisheries management tools ranging from input controls, output controls, conservation measures, traditional and/or customary management, and market-based instruments;
- Utilize the CTI as a forum for knowledge sharing on best aquaculture practices and experiences that should not be emulated; and
- Petition the US government to strictly monitor the entry of coral and coral species to separate those listed under the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES) and those that are allowed, and prosecute illegal trade.

(iv) Strengthen CTI as a regional institution through partnerships and alignments with agencies working on specific elements of the CTI Plan of Action that can be enhanced
- Align and build relationships with other organizations outside the CTI that are specifically working on fisheries management, including addressing IUU fishing and enforcement activities related to trade on endangered species and straddling stocks, to leverage resources and sustain knowledge sharing;
- Align and build relationships with other organizations outside the CTI that are specifically working on trade, including trade in endangered species (e.g., corals); and
- Engage other agencies outside the fisheries and/or environment milieu to participate and cofinance data generation, which can be used for poverty mapping, investment planning, and climate adaptation; and where such agencies are related to planning, statistics, social welfare and human development, health and nutrition, and local government oversight, among others.

(v) Conduct research, monitoring, response, and feedback systems to strengthen the marketing position of the CT6 as an organized bloc
- Conduct a feasibility study to assess whether the CTI can function as a marketing bloc for fisheries products (both from wild harvest and aquaculture), with particular emphasis on comparative advantages, product differentiation, standard setting, and branding; and
- Conduct value chain analysis for fisheries and aquaculture commodities to assess the distribution of profits and/or rents and derive sustainable financing modalities.

(vi) Conduct a comprehensive and extended cost–benefit analysis for commodities that are threatened or endangered (e.g., corals) to account for indirect and non-use values of an entire suite of ecosystem services

- Revisit the policy that allows the export of corals owing to their huge direct fisheries value; and large, critical ecosystem service values for coastal protection and climate change adaptation; and
- Conduct valuation of ecosystem services associated with coastal habitats to inform trade policies and investments in coastal habitat protection.

(vii) Forge private–public partnerships (PPPs) to generate revenues that can be plowed back for management purposes and improve livelihoods from supply/value chain participants engaged in sustainable management

- Improve the availability of fisheries goods and related ecosystem services to help minimize unfair, unsustainable, and perverse practices (e.g., hoarding and price manipulation); and, thereby, contribute to good environmental governance of the fisheries social and ecological system;
- Forge PPPs to enhance the feasibility of coral farming in CT6 countries;
- Allocate revenues from fisheries to invest in social enterprises, which capacitate fishers to improve incomes through sustainable fishery yield practices, and in enabling mechanisms that empower them to access information and capacity-building opportunities; and
- Promote the social marketing of products and good practices of social enterprises to enhance the vertical and horizontal communication process.

(viii) Develop cost-effective data collection methods linked to a decision support system to allow periodic assessment of the status of subsistence fisheries, including the number of fishers, production, gears used, catch disposition, and marketing; and allow for adjustments of fishery management

- Consider the role of local governments, academic institutions, and other government agencies in data collection and use; and
- Emphasize the role of subsistence fisheries (or the subsistence fishery sector) in spurring local economies, and develop methods to derive relevant statistics at the national and regional levels.

In conclusion, the ecosystem approach to fisheries management requires coordinated coastal and ocean resources governance at the local, national, and regional scales to overcome the challenges of fisheries overexploitation, degraded ecosystems, and decline of goods and services. Sustaining fisheries requires building the capacity of national constituencies and regional bodies to transform and change behavior individually and collectively. The CTI offers the opportunity to accelerate and improve the beneficial impacts that lead to addressing the sustainable development concerns of fisheries. Achieving synergies through PPP; knowledge management; and cooperation in social, ecological, and governance incentive systems could help accelerate the attainment of CTI goals as enunciated in the RPOA and in national plans of action.

Appendix

List of Species in CT6 Countries
(within FAO Landings Dataset, 1950–2010)

Coral Triangle FAO Landings (ASFIS Species)	Ecosystem	Taxonomy	Human Use
Abalones nei	Demersal marine	Mollusk	Consumed
Akiami paste shrimp[a]	Demersal marine	Crustacean	Consumed
Albacore	Ocean	Fish	Consumed
Anadara clams nei	Reef-associated	Mollusk	Consumed
Anchovies, etc. nei	Ocean	Fish	Consumed
Aquatic invertebrates nei	Reef-associated	Invertebrate	Consumed
Atlantic white marlin	Ocean	Fish	Consumed
Bali sardinella[a]	Ocean	Fish	Consumed
Banana prawn	Demersal marine	Crustacean	Consumed
Barracudas nei	Reef-associated	Fish	Consumed
Batfishes	Reef-associated	Fish	Consumed
Bigeye scad	Reef-associated	Fish	Consumed
Bigeye tuna	Ocean	Fish	Consumed
Bigeyes nei	Reef-associated	Fish	Consumed
Black marlin	Ocean	Fish	Consumed
Black pomfret[a]	Ocean	Fish	Consumed
Blacklip abalone	Reef-associated	Mollusk	Consumed
Blood cockle[a]	Demersal marine	Mollusk	Consumed
Blue mackerel[a]	Ocean	Fish	Consumed
Blue marlin	Ocean	Fish	Consumed
Blue swimming crab	Estuarine	Crustacean	Consumed
Bombay-duck[a]	Ocean	Fish	Consumed
Bullet tuna[a]	Ocean	Fish	Consumed
Butterfishes, pomfrets nei	Ocean	Fish	Consumed
Carangids nei	Reef-associated	Fish	Consumed
Cephalopods nei	Ocean	Mollusk	Consumed
Chocolate hind[a]	Reef-associated	Fish	Consumed
Chub mackerel	Ocean	Fish	Consumed
Clams, etc. nei	Ree-associated	Mollusk	Consumed
Clupeoids nei	Ocean	Fish	Consumed

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Appendix *continued*

Coral Triangle FAO Landings (ASFIS Species)	Ecosystem	Taxonomy	Human Use
Cobia	Reef associated	Fish	Consumed
Commercial top[a]	Demersal marine	Mollusk	Consumed
Common dolphinfish	Reef-associated	Fish	Consumed
Common squids nei	Ocean	Mollusk	Consumed
Conger eels, etc. nei	Demersal marine	Fish	Consumed
Croakers, drums nei	Reef-associated	Fish	Consumed
Cupped oysters nei[a]	Mangrove	Mollusk	Consumed
Cuttlefish, bobtail squids nei	Reef-associated	Mollusk	Consumed
Daggertooth pike conger[a]	Demersal marine	Fish	Consumed
Demersal percomorphs nei	Demersal marine	Fish	Consumed
Dogfish sharks nei[a]	Reef-associated	Elasmobranch	Consumed
Eagle rays nei[a]	Ocean	Elasmobranch	Consumed
Eeltail catfishes[a]	Freshwater	Fish	Consumed
Emperors(=Scavengers) nei	Reef-associated	Fish	Consumed
Endeavour shrimp	Ocean	Crustacean	Consumed
False trevally	Ocean	Fish	Consumed
Flatfishes nei	Demersal marine	Fish	Consumed
Flatheads nei[a]	Estuarine	Fish	Consumed
Flyingfishes nei	Ocean	Fish	Consumed
Fourfinger threadfin[a]	Demersal marine	Fish	Consumed
Frigate and bullet tunas	Ocean	Fish	Consumed
Frigate tuna[a]	Ocean	Fish	Consumed
Fusiliers nei	Reef-associated	Fish	Consumed
Gastropods nei	Reef-associated	Mollusk	Consumed
Giant tiger prawn	Demersal marine	Crustacean	Consumed
Glassfishes	Freshwater	Fish	Consumed
Goatfishes	Reef-associated	Fish	Consumed
Goatfishes, red mullets nei	Reef-associated	Fish	Consumed
Gobies nei	Reef-associated	Fish	Consumed
Goldstripe sardinella[a]	Ocean	Fish	Consumed
Greasy grouper[a]	Reef-associated	Fish	Consumed
Great barracuda[a]	Reef-associated	Fish	Consumed
Greater lizardfish[a]	Reef-associated	Fish	Consumed
Green mussel	Freshwater	Mollusk	Consumed
Groupers nei	Reef-associated	Fish	Consumed
Groupers, seabasses nei	Reef-associated	Fish	Consumed
Grunts, sweetlips nei	Reef-associated	Fish	Consumed
Guitarfishes, etc. nei[a]	Demersal marine	Fish	Consumed

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Appendix *continued*

Coral Triangle FAO Landings (ASFIS Species)	Ecosystem	Taxonomy	Human Use
Hairtails, scabbardfishes nei	Demersal marine	Fish	Consumed
Halfbeaks nei	Reef-associated	Fish	Consumed
Hammerhead sharks, etc. nei[a]	Ocean	Elasmobranch	Consumed
Hard clams nei[a]	Demersal marine	Mollusk	Traded
Hard corals, madrepores nei[a]	Reef-associated	Crustacean	Traded
Honeycomb grouper[a]	Reef-associated	Fish	Consumed
Humpback grouper[a]	Reef-associated	Fish	Consumed
Humphead wrasse[a]	Reef-associated	Fish	Consumed
Indian halibut[a]	Demersal marine	Fish	Consumed
Indian mackerel	Ocean	Fish	Consumed
Indian mackerels nei	Ocean	Fish	Consumed
Indian scad[a]	Reef-associated	Fish	Consumed
Indo-Pacific king mackerel	Ocean	Fish	Consumed
Indo-Pacific sailfish	Ocean	Fish	Consumed
Indo-Pacific swamp crab	Mangrove	Crustacean	Consumed
Indo-Pacific tarpon	Estuarine	Fish	Consumed
Jacks, crevalles nei	Reef-associated	Fish	Consumed
Jellyfishes nei	Ocean	Fish	Consumed
Jobfishes nei[a]	Reef-associated	Fish	Consumed
Kawakawa	Demersal marine	Fish	Consumed
Largehead hairtail[a]	Demersal marine	Fish	Consumed
Leopard coralgrouper[a]	Reef-associated	Fish	Consumed
Lizardfishes nei	Reef-associated	Fish	Consumed
Longtail tuna	Ocean	Fish	Consumed
Mackerel sharks, porbeagles nei[a]	Ocean	Elasmobranch	Consumed
Mackerels nei	Ocean	Fish	Consumed
Mangrove red snapper[a]	Reef-associated	Fish	Consumed
Mantas, devil rays nei[a]	Reef-associated	Elasmobranch	Consumed
Marine crabs nei	Estuarine	Crustacean	Consumed
Marine crustaceans nei	Demersal marine	Crustacean	Consumed
Marine fishes nei[a]	Grouped as "reef-associated" for Papua New Guinea and Solomon Islands	Fish	Various
Marine mollusks nei	Demersal marine	Mollusk	Consumed
Marine shells nei	Reef-associated	Mollusk	Traded
Marine turtles nei	Reef-associated	Turtles	Traded
Marlins, sailfishes, etc. nei[a]	Ocean	Fish	Consumed
Metapenaeus shrimps nei[a]	Demersal marine	Crustaceans	Consumed

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Appendix *continued*

Coral Triangle FAO Landings (ASFIS Species)	Ecosystem	Taxonomy	Human Use
Mojarras(=Silver-biddies) nei	Reef-associated	Fish	Consumed
Monocle breams[a]	Reef-associated	Fish	Consumed
Moonfish[a]	Reef-associated	Fish	Consumed
Mullets nei	Estuarine	Fish	Consumed
Narrow-barred Spanish mackerel	Ocean	Fish	Consumed
Natantian decapods nei	Demersal marine	Crustaceans	Consumed
Needlefishes nei	Reef-associated	Fish	Consumed
Octopuses, etc. nei	Reef-associated	Mollusk	Consumed
Pacific bluefin tuna[a]	Ocean	Fish	Consumed
Pearl oyster shells nei	Reef-associated	Mollusk	Traded
Pelagic percomorphs nei[a]	Ocean	Fish	Consumed
Penaeus shrimps nei	Demersal marine	Crustaceans	Consumed
Percoids nei	Ocean	Fish	Consumed
Pickhandle barracuda[a]	Reef-associated	Fish	Consumed
Ponyfishes(=Slipmouths) nei	Reef-associated	Fish	Consumed
Ponyfishes(=Slipmouths)	Reef-associated	Fish	Consumed
Porgies, seabreams nei	Reef-associated	Fish	Consumed
Queenfishes	Reef-associated	Fish	Consumed
Rainbow runner	Reef-associated	Fish	Consumed
Rainbow sardine	Reef-associated	Fish	Consumed
Rays, stingrays, mantas nei	Reef-associated	Elasmobranch	Consumed
Red bigeye[a]	Reef-associated	Fish	Consumed
Requiem sharks nei[a]	Reef-associated	Elasmobranch	Consumed
Sardinellas nei	Ocean	Fish	Consumed
Sawfishes[a]	Ocean	Fish	Consumed
Scads nei	Reef-associated	Fish	Consumed
Scallops nei	Demersal marine	Mollusk	Consumed
Scats	Reef-associated	Fish	Consumed
Sea catfishes nei	Estuarine	Fish	Consumed
Sea cucumbers nei	Reef-associated	Echinoderm	Traded
Sea urchins nei	Reef-associated	Echinoderm	Consumed
Seerfishes nei[a]	Ocean	Fish	Consumed
Sergestid shrimps nei	Demersal marine	Crustaceans	Consumed
Sharks, rays, skates, etc. nei	Ocean	Elasmobranch	Consumed
Short mackerel	Ocean	Fish	Consumed
Short neck clams nei	Demersal marine	Mollusk	Consumed
Shortbill spearfish	Ocean	Fish	Consumed
Shortfin mako	Ocean	Elasmobranch	Consumed

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Appendix *continued*

Coral Triangle FAO Landings (ASFIS Species)	Ecosystem	Taxonomy	Human Use
Sillago-whitings	Demersal marine	Fish	Consumed
Silver grunt[a]	Reef-associated	Fish	Consumed
Silver pomfret[a]	Ocean	Fish	Consumed
Silver sillago[a]	Reef-associated	Fish	Consumed
Silversides(=Sand smelts) nei	Freshwater	Fish	Consumed
Skipjack tuna	Ocean	Fish	Consumed
Slipper cupped oyster	Mangrove	Mollusk	Consumed
Slipper lobsters nei	Demersal marine	Crustaceans	Consumed
Snappers nei	Reef-associated	Fish	Consumed
Snappers, jobfishes nei	Reef-associated	Fish	Consumed
Southern bluefin tuna	Ocean	Fish	Consumed
Spinefeet(=Rabbitfishes) nei	Reef-associated	Fish	Consumed
Sponges	Reef-associated	Sponges	Traded
Spotted sardinella[a]	Reef-associated	Fish	Consumed
Spotted sicklefish	Reef-associated	Fish	Consumed
Squillids nei	ocean	Crustaceans	Consumed
Stingrays, butterfly rays nei[a]	demersal marine	Elasmobranch	Consumed
Stolephorus anchovies nei	Ocean	Fish	Consumed
Striped bonito[a]	Ocean	Fish	Consumed
Striped marlin	Ocean	Fish	Consumed
Surgeonfishes nei	Reef-associated	Fish	Consumed
Sweetlips, rubberlips nei[a]	Reef-associated	Fish	Consumed
Swordfish	Ocean	Fish	Consumed
Terapon perches nei[a]	Reef-associated	Fish	Consumed
Threadfin breams nei	Reef-associated	Fish	Consumed
Threadfins, tasselfishes nei	Reef-associated	Fish	Consumed
Thresher sharks nei[a]	Ocean	Elasmobranch	Consumed
Tonguefishes[a]	Estuarine	Fish	Consumed
Torpedo scad	Reef-associated	Fish	Consumed
Triggerfishes, durgons nei	Reef-associated	Fish	Consumed
Trochus shells	Reef-associated	Mollusk	Consumed
Tropical spiny lobsters nei	Reef-associated	Crustaceans	Consumed
Tuna-like fishes nei	Ocean	Fish	Consumed
Turban shells nei[a]	Demersal marine	Mollusk	Traded
Various squids nei	Ocean	Mollusc	Consumed
Wahoo	Ocean	Fish	Consumed
Whitespotted wedgefish[a]	Demersal marine	Fish	Consumed
Wolf-herrings nei	Reef-associated	Fish	Consumed

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Appendix *continued*

Coral Triangle FAO Landings (ASFIS Species)	Ecosystem	Taxonomy	Human Use
Wrasses, hogfishes, etc. nei	Reef-associated	Fish	Consumed
Yellowfin tuna	Ocean	Fish	Consumed
Yellowstripe scad[a]	Reef-associated	Fish	Consumed

ASFIS = Aquatic Sciences and Fisheries Information System, FAO = Food and Agriculture Organization of the United Nations, nei = not elsewhere identified.

[a] ASFIS species groups with are not included in Newton et al. (2007).

Source: Based on K. Newton, I.M. Cote, G.M. Pilling, S. Jennings, and N.K. Dulvy. 2007. Current and Future Sustainability of Island Coral Reef Fisheries. *Current Biology*. 17(7). p. 655; and R. Froese and D. Pauly, eds. 2013. FishBase. www.fishbase.org, version (accessed February 2013).

Economics of Fisheries and Aquaculture in the Coral Triangle

Marine resources in the Coral Triangle provide food, income, and jobs to its more than 350 million residents. However, the countries bordering this species-rich area—Indonesia, Malaysia, the Philippines, Papua New Guinea, Solomon Islands, and Timor-Leste—share closer links in their ecology than in their economy. Case studies explore the potential benefits of integrating these countries' small-scale fisheries into global markets by developing opportunities for market differentiation, ensuring equitable distribution of benefits across the supply chain, and lastly, recognizing fisheries values beyond those measurable by national income accounts.

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