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Technical Assistance Consultant's Report

Economics of Fisheries and Aquaculture in the Coral Triangle (EFACT)

FINAL REPORT

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AASI	Aquarium Arts Solomon Islands
ACIAR	Australian Centre for International Agricultural Research
ADB	Asian Development Bank
AMAF	ASEAN Ministerial Meeting on Agriculture and Forestry
AMME	ASEAN Ministerial Meeting on the Environment
APEC	Asia-Pacific Economic Cooperation
ASEAN	Association of Southeast Asian Nations
ASEAN-WEN	ASEAN Wildlife Enforcement Network
ASFIS	Aquatic Sciences and Fisheries Information System
ATSEA	Arafura and Timor Seas Ecosystem Action
AUS	Australia
AusAID	Australian Agency for International Development
BARC	Brackish Water Aquaculture Research Center
BAS	Bureau of Agricultural Statistics
BFAR	Bureau of Fisheries and Aquatic Resources
BOT	balance of trade
CBD	Convention on Biological Diversity
CBRM	community-based resource management
CCT	conditional cash transfer
CEA	California Environmental Associates
CHN	People's Republic of China
CIESIN	Center for International Earth Science Information Network
CITES	Convention on International Trade in Endangered *Species* of Wild Fauna and Flora
CPUE	catch per unit effort
CT	Coral Triangle
CTI	Coral Triangle Initiative
CTI-CFF	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, Timor-Leste)
CT-SEA	Coral Triangle – Southeast Asian countries (Indonesia, Malaysia, Philippines)
CT-Pacific	Coral Triangle – Pacific (Papua New Guinea, Solomon Islands, Timor-Leste
DA	Department of Agriculture
DANIDA	Danish International Development Agency
DFMR	Department of Fisheries and Marine Resources
DGA	Directorate General of Aquaculture
DSWD	Department of Social Welfare and Development
EAFM	ecosystem approach to fisheries management
EBFM	ecosystem-based fisheries management
EBM	ecosystem-based management
EEPES	environmental economics and payment for ecosystem services
EEZ	exclusive economic zone
EFACT	Economics of Fisheries and Aquaculture in the Coral Triangle
EU	European Union
FAO	Food and Agriculture Organization of the United Nations
FARMC	Fisheries and Aquatic Resources Management Council
FCR	food conversion ratio
FFA	Fisheries Forum Agency
FGD	focus group discussion
FIPS	Fisheries and Aquaculture Statistics and Information Service
FMA	fisheries management area
FOB	free-on-board

FRWG	Financial Resources Working Group
GDP	gross domestic product
GOFAR	Group of Fisheries and Aquatic Research
gt	gross ton
GVA	gross value added
HACCP	hazard analysis and critical control point
ICLARM	International Center for Living Aquatic Resources
ICM	integrated coastal management
ISSCAAP	International Standard Statistical Classification of Aquatic Animals and Plants
IUU	Illegal, unreported, and unregulated fishing
KI	knowledge integrator
KII	key informant interview
km	kilometer
KM	knowledge management
LEAP	local early adaptation plan
LGA	local government association
LGU	local government units
LRF	live reef fish
LRFT	live reef fish trade
MAF	Ministry of Agriculture and Fisheries
MCS	monitoring, control, and surveillance
MECDM	Ministry of Environment, Climate Change, Disaster Management and Meteorology
MFMR	Ministry of Fisheries and Marine Resources
MMAF	Ministry of Marine Affairs and Fisheries
MPA	marine protected area
MSY	maximum sustainable yield
NAP 3	Third National Agricultural Policy
NAP	National Agricultural Policy
NARI	National Agicultural Research Institute
NDRRMC	National Disaster and Risk Reduction Management Council
NEDA	National Economic and Development Authority
NFA	National Fisheries Authority
NFRDI	National Fisheries Research and Development Institute
NGO	nongovernment organization
NPOA	national plan of action
NSAP	National Stock Assessment Program
OFWG	Oceans and Fisheries Working Group
PCSD	Palawan Council for Sustainable Development
PEMSEA	Partnerships in Environmental Management for the Seas of East Asia
PES	payment for ecosystem services
PhP	Philippine Peso
PLACE II	Population, Landscape and Climate Estimates, v.2
PNG	Papua New Guinea
REAP	regional early adaptation plan
ROI	return on investment
ROW	rest of the world
RPOA/NPOA	Regional/National Plan of Action
SARS	severe acute respiratory syndrome
SCTR	State of the Coral Triangle Report
SEAFDEC	Southeast Asian Fisheries Development Center
SEAFDEC-AQD	SEAFDEC-Aquaculture Department
SF	sustainable financing
SIMFMR	Solomon Islands Ministry of Fisheries and Marine Resources

SMIFMR	Strategy for the Management of Inshore Fisheries and Marine Resources
SPC	Secretariat of the Pacific Community
SPREP	Secretariat of the Pacific Regional Environment Programme
SSME	Sulu Sulawesi Marine Eco-region
T	ton
TA	Technical Assistance
TEV	total economic value
TNC	The Nature Conservancy
TURF	territorial use right
UNFPA	United Nations Population Fund
UNDP	United Nations Development Programme
WCO	World Customs Organization
WCPFC	Western and Central Pacific Fisheries Commission
WCPO	Western and Central Pacific Ocean
WorldFish	WorldFish Center
WWF	World Wildlife Fund

EXECUTIVE SUMMARY

The Economics of Fisheries and Aquaculture in the Coral Triangle (EFACT) is a report 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) *Regional Technical Assistance for Regional Cooperation in Knowledge Management (KM), Policy, and Institutional Support to the Coral Triangle Initiative (CTI) (TA 7307-REG)*.

As a knowledge product derived from the project's three years of work in the CTI, EFACT was written to inform actions and policy discourse in the implementation of the CTI regional and national plans of action (NPOAs). New knowledge was derived through primary data collection, and existing knowledge was organized and analyzed using a regional perspective and an economic lens. The report concludes with a regional call to action.

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

In 2010, the coastal fisheries resources provided food, sustained incomes, and fueled trade and enterprise for more than 373 million people living in the in the six CTI countries (CT6)[1], a third of whom reside within 10 km of the coastline. In 2010, the CT6 contributed 11.3% (19.1 million tons [t]) to global capture fisheries and aquaculture production. Of this production, some 69%, or 13.2 million t, comprised food fish, representing 10% of the global food supply, while the rest consisted of aquatic plants. Most food fishes are still obtained from the marine environment through capture fisheries (69%) and marine and brackishwater aquaculture (13%).

Fish and aquatic invertebrates are important protein sources for most countries in Asia and the Pacific. Fish per capita supply of Malaysia, Philippines, and Indonesia remained above the average values for Asia in 2009. The supply of fish per capita in Malaysia, Indonesia, and the Philippines has been increasing since 1961, with Malaysia showing the fastest rate of increase followed by the Philippines and Indonesia. 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 the CT6 with 1.27% of the aggregate CT6 population, or 2.04% of total persons employed in the CT6 in 2009.[2] Assuming an average household size of 4, the total number of people directly dependent on fisheries for livelihood in the Coral Triangle is estimated at 18.4 million, or 5% of the aggregate population in the CT6, in 2009.

Fisheries and aquaculture production in the CT6 comprises between 1.2% and 6.8% of gross domestic product (GDP), although issues pertaining to the collection of official statistics abound, including the difficulty of estimating the volume and value of subsistence fisheries and the lack of coordination between fisheries and statistics/planning agencies, which affects the credibility of the numbers.

Of the fisheries production in the CT6, mackerels (scombrids), anchovies, and sardines (clupeids) comprise 53%, while reef-associated species comprise 32%. Tuna is an important fishery commodity in the Coral Triangle (CT). In 2009, 46% of all tuna catches in the Western and Central Pacific (WCP), valued at $1.5 billion, came from the national waters of Indonesia, Philippines, PNG, and the Solomon Islands. In both PNG and the 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 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 CT and are exploited for sale or subsistence. The value of coral reefs to capture fisheries production in the CT was estimated by identifying reef-associated fish catches in the dataset of the Food and Agriculture Organization of the United Nations (FAO), determining the percentage composition of reef-associated fishes in the total capture fisheries production for each

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[1] viz., Indonesia, Malaysia, Papua New Guinea (PNG), the Philippines, Solomon Islands, and Timor-Leste.

[2] Total population in the CT6 in 2009 was 365,394,353; 62.14% of these were employed (15 years and older). Data from the World Bank. Employment to population ratio: http://data.worldbank.org/indicator/ SL.EMP.TOTL.SP.ZS; population data: http://data.worldbank.org/indicator/SP.POP.TOTL

country, and 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 the CT6 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 the CT6, is taken into account.

CT6 fish production has been consistently increasing since 1950, 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 in the last decade. The rapid increase in total fisheries production in the CT6 from 2004 to 2009 was primarily due to the development of aquaculture in Indonesia and the Philippines.

The increasing trends in production for both marine capture fisheries and aquaculture can mislead people to believing that fishing in the CT6 is sustainable and well within carrying capacity limits. However, 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 the fisheries in the CT6.

A recent FAO report on the status of world marine fishery resources concluded that majority of fish stocks in Indonesia, the Philippines, and Malaysia are considered to be at least fully exploited. Demersal finfish fisheries of the CT6 are mostly fully exploited or overexploited. This is true in Indonesia, where overfishing occurs in 5 out of 11 designated fisheries management areas (FMAs). In Malaysia, scientific surveys conducted from 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. Recent assessments by the Western and Central Pacific Fisheries Commission (WCPFC) 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 the CT6 is estimated to increase to a moderate value of 17.1 million t by 2020, with a range of 15.5–19.4 million t, compared to the production of 13.2 million t in 2010. Based on population projections, this estimated fish production could mean an annual per capita fish supply of 33.0–45.0 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. At the country level, fish per capita supply was also projected using two time frames, 2001–2010 and 2007–2009. On average, per capita fish supply in the CT6 increased by 32% and 44% for the two periods considered. The increase in Timor-Leste was consistent for both periods, registering an increase of at least 70%, consistent with the government's aggressive efforts to improve productivity in both fish capture and culture.

Aquaculture Development Trends and Implications in the Coral Triangle

Aquaculture is seen by most CT countries as contributing to food security, poverty alleviation, and export revenues, but the CTI Regional Plan of Action (RPOA) has been silent on its benefits and impacts, while the National Plans of Action (NPOAs) have given varied treatments. This report focuses on the demand of aquaculture for trash fish for reduction purposes, but recognizes other interactions between capture fisheries and aquaculture, including (i) alien species introduction mainly for aquaculture purpose 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 growout, such as in the live reef fish industry). Notable are the different aquaculture strategies employed by the CT6 – efforts in the Pacific countries are more focused on the expansion of freshwater aquaculture, while the Southeast Asian countries are concentration on high-value carnivorous species.[3] Aside from production and economic inefficiencies, the increasing demand for trash fish has numerous impacts on levels of harvesting and consumption of commercial species. The fishkills in the Philippines, which can be ultimately traced to an overheated aquaculture sector, are a case in point. While the damages associated with

3 For example, Malaysia will require at least 800,000 t of trash fish costing roughly $640 million to achieve a target production of 165,000 t of marine fish.

fishkills are localized and appear insignificant when compared to the total sector revenues, what is missing in the analysis are the costs associated with linkages with other economic sectors, losses incurred by various government agencies, and their 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 – be they fishers, fish processors, feed suppliers, or fish farmers. Economic analysis informs the optimal use of scarce resources, and policymaking uses economic instruments to monitor the attainment of objectives.

Connectivities in the Coral Triangle

The CT6 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 tuna; 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 exchange: (i) in the South China Sea between the Spratly Islands and the Philippines; (ii) the reefs in the western part of the CT between the Java-Sulu Archipelago and the Bismarck–Banda Sea and the eastern portions of Banda Sea; and (iii) between the reefs of PNG and the Solomon Islands. In-country conservation efforts are as important as regional action given that coral reefs are largely self-recruiting.

Economic connectivity is demonstrated by trade between and among the CT6 and between the individual CT countries and the rest of the world (ROW). The volume of trade in fish and fishery products among the CT6 is less than the trade with countries outside the CT. For the CT6, as a region trading with the ROW, there was a consistent surplus over the nine-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 varies among the CT6. The Philippines exports only 7% of its total fish production, while PNG and the Solomon Islands export more than half of the catches from their domestic fleets.

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

Subsistence Fisheries in the Coral Triangle

The subsistence fisheries in the CT6 were given attention in this report in recognition of the issues identified by FAO: they are under-reported, 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 the Solomon Islands, nearly half of all women and 90% of men in most rural households engage in fishing. This study estimates 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 the household, which is almost half of the country’s population. Using data derived from a survey conducted by the World Fish Center (WorldFish) in the Solomon Islands and this project, the use and non-use values of coral reefs were estimated in four communities in the Western and Central Provinces, with the former consisting of two communities with a history of aquarium and curio trade. Coral reefs provide an average of SI$18,000–75,000 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$9,600–43,000 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, it is estimated that the subsistence and cash value of reef fish is SI$300–1,000 million per year (US$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, with the objectives of (i) obtaining the level of dependency of village households on fisheries-related activities for their livelihoods, and (ii) enhancing the capacity of the Ministry of Agriculture and Fisheries (MAF) 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 fulfill most of the criteria for subsistence fisheries, including size of boat, number of crew, gear type, ownership, time spent in fishing, except for (i) the disposal of catch, because the surveyed respondents‘ catches were primarily for sale, with a portion for domestic/own consumption; and (ii) the households' integration into the economy, since much of the fishing and disposal was via market channels. Overall, the profiles indicate that subsistence level 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 the household, total fish production in support of household food needs is about 195,000 t/yr for the Philippines, with the value representing 22% of the food poverty threshold level.

Small-scale fishing, which accounts for the bulk of employment in the sector in the CT, 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 CT region. If it is assumed 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 in the Coral Triangle

Opportunities exist for small fishers in the CT6 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 of 17-21% for the handliners of Mindoro and Lagonoy Gulf. Though 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, though profitable for fishers and cagers, hastens overexploitation of wild grouper due to the preference for juveniles, which are cheaper and can be caged. Contrast this value retention with coral trade in the Solomon Islands, where a harvester earns only 1–2% of the total product value owing to huge transportation costs and market isolation. Nevertheless, the analysis shows that coral trade is an important source of cash income at the community level, supporting non-food requirements. Options to improve on value addition, adherence to economies of scale, and full government support can reinvigorate interest in coral farming as an option to wild harvest.

Assuring Sustainable Fisheries Development through Ecosystem Resiliency and Food Security

Despite the importance of the CT 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. The CT6 have high socioeconomic vulnerability, considering that 16.6% of the population are poor and around 13% are undernourished. Poverty incidence in the coastal fishing communities of the CT6 is generally higher than the national average, and the climate change risk is high. In many of the Pacific countries, importation of food is increasing because of the 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 results in significant economic losses, as measured through opportunity costs, faster pace of resource degradation, and unequal resource distribution. Some studies have estimated worldwide annual production from IUU operations to range between 11–26 million t, accounting for about 10–22% of the world's total fisheries production and valued at about $10–23.5 billion per year.

Results of a mini survey conducted by this project among fisheries officials and staff, researchers, and experts in the CT6 showed that fisheries management in the CT employs both input and output controls as well as some conservation measures which can be classified under ecosystem approach to fisheries management (EAFM). Input controls are more commonly employed in the CT6 than regulations on catch rates and catch volumes. Limits on fishing grounds through zoning, establishment of fish sanctuaries or fishing exclusion zones, as well as protection of critical fish habitats and spawning aggregation sites, are implemented in all of the CT6 to varying extents and degrees of enforcement. Conservation measures are also being implemented, and include 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 Southeast Asian countries, but are not apparent in the Pacific, while traditional fisheries management measures are more widely applied in the Pacific than in the Southeast Asian countries. Output controls are least employed by the CT6, owing mainly to the multi-species and multi-gear nature of the fisheries as well as 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, which 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 contexts: (i) geographical expansion; (ii) functional expansion; and (iii) temporal considerations. Geographical expansion can involve (i) integrating management from the town or barangay level to the baywide, municipal level or networks of towns; or (ii) 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 of the form of a livelihood approach that explores the properties of networks of families and communities, while temporal expansion involves going beyond the standard monitoring process to one that considers future scenarios that consider climate change impacts.

CHAPTER I
INTRODUCTION

A. Background and Purpose of the Study

The Asian Development Bank (ADB) Regional Technical Assistance for Regional Cooperation in Knowledge Management (KM), Policy, and Institutional Support to the Coral Triangle Initiative (CTI) (TA 7307-REG) is the first ADB support to the Coral Triangle Initiative (CTI). The TA has four expected outputs: (i) regional cooperation strengthened; (ii) regional learning mechanisms established; (iii) a communication and information dissemination plan implemented; and (iv) sustainable financing (SF) schemes in support of the national plans of action (NPOAs) established in the six countries in the Coral Triangle region (CT6), namely: Indonesia, Malaysia, Papua New Guinea (PNG), the Philippines, Solomon Islands, and Timor-Leste. One of the major issues that the TA aimed to address is the lack of accessibility of information to decision makers for policy and decision making. As the CT6 National Plans of Action (NPOAs) 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.

At the regional inception workshop held at the ADB headquarters in Manila, Philippines on 26-27 April 2012, key stakeholder representatives, including major development partners of the CT6, and ADB agreed to narrow the focus of the TA to three focal areas (sustainable financing, environmental economics and payment for ecosystem services (EEPES), and preparation of the State of the Coral Triangle Report [SCTR]), and to build and pilot-test a KM system around the essential processes of knowledge capture and creation, storage and retrieval, sharing and dissemination, and use and enrichment in these three focus areas.

Moreover, the Government of Australia, through the Australian Agency for International Development (AusAID), offered additional funding to support data collection activities related to the economics of coastal fisheries and aquaculture in the three Pacific CTI countries (PNG, Solomon Islands, and Timor-Leste), where data are relatively scarce and less robust than in the Southeast Asian countries of the CT. The research work would collect/collate information through focus group discussions (FGDs), key informant interviews (KIIs), and short surveys, on the economics of fisheries and aquaculture. The study would include profiling of the fisheries sector in the three countries in terms of production, trade, contribution to employment, etc., and discussion of governance instruments, specifically those that are in place to manage the fisheries. The study in the three countries would be conducted with a view to influencing policy and helping build institutional capacity through information sharing and knowledge management. This study was later expanded to cover the three Southeast Asian CT countries.

> **Excerpt from the Proposal to the Australian Government**
>
> *The study will focus on the importance of coastal fisheries/aquaculture to national economies, trade within and outside of the CT, and options to improve the socioeconomic well-being of people who are dependent on the state of the resources. The study will be conducted with a view to influencing policy in the Pacific countries and helping build institutional capacity in these countries through the sharing of information and knowledge management.*

In mid-2011, the Australian Government announced a fresh package of assistance to the Pacific CTI countries, including a grant to the WorldFish Center (WorldFish) in the Solomon Islands for the conduct of a study to evaluate coral exports, including a comparison of retained benefits and costs associated with wild harvest vis-à-vis farming of corals. The study, which was co-financed by ADB, reviewed previous attempts to analyze value chains of coral exports with an additional focus on environmental costs and notions of non-use and indirect values.

B. Features of the EFACT Study

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

EFACT responds to the Regional and National Plans of Action (RPOA/NPOAs), specifically Goal 2, Target 2 of the RPOA, which is a succinct articulation of the perceived interactions among human populations, fisheries, and biodiversity through a program dubbed "Coastfish." In both the RPOA and NPOAs, the Coastfish program is envisioned as an initiative that addresses livelihoods, incomes, food security, and poverty issues at identified sites. Targeting of coastal areas and design of investment programs that will contribute to the goal of poverty reduction must be planned carefully and with sufficient basis, also considering the existing initiatives as possible models or best practices. Some of these best practices include existing modalities to fund activities of small-scale fishers, livelihood approaches, and approaches to aquaculture management. The relevance of this EFACT study lies in the generation of data that will guide investment planning, specifically site selection and characterization of fisher communities (household size, density, current and potential incomes from fishing/fish farming and other livelihood sources, fishing practices, dependence on fisheries resources, and current fish consumption patterns).

Although the live reef fish trade generates millions of dollars in export revenues for the CT6, it is necessary to undertake an assessment of the trickle-down effects of pricing and how price nuances may, in fact, hasten the exploitation (or overexploitation) of live reef fish resources. Of interest are 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 on live reef fish, which was supported by World Wildlife Fund (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 1, EAFM, includes (i) determining the extent of dependency of coastal communities on fisheries resources; (ii) improving their income base through alternative livelihoods, including 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 to traditional fisheries management, which focuses only on maximizing economic benefits, and is consistent with the EAFM framework recognized by the present study. Among the actions requiring fisheries economics analysis are: (i) the use of 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 the tuna fishery;[4] and (iv) providing a status report on the live reef and ornamental fish trade. Plans to update a fishery dependence survey together with The Nature Conservancy (TNC) did not eventuate, but knowledge gained in the tuna value chain analysis may be replicated to inform investment planning for the commercial tuna sector.

In the Solomon Islands, a two-phased approach to NPOA implementation has been adopted, with the first phase involving the identification of pilot provinces. Criteria used for the selection of Phase 1 sites include human development and poverty indices, dependency of rural population on marine resources, and subsistence indices. The 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 and can be jointly addressed through appropriate communication methods.

[4] The tuna fishery is not within the scope of the study funded by AusAID, which focuses on small-scale coastal fisheries.

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

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

In the Philippines, a workshop was co-organized with WorldFish with participation from (i) three agencies under the Department of Agriculture (DA) — Bureau of Fisheries and Aquatic Resources (BFAR), National Fisheries Research and Development Institute (NFRDI), and Bureau of Agricultural Statistics (BAS); (ii) selected local government units (LGUs); and (iii) local nongovernment organizations (NGOs). The workshop reviewed the state of fisheries statistics collection, with the purpose of assessing how local collection protocols of LGUs can be used to verify, enhance, and countercheck the survey results by the national agencies.

At the regional level, questionnaires were sent out by the project to determine the use and effectiveness of fisheries management interventions across the CT6, including input and output controls, protection and conservation measures, subsidies, and traditional management systems. The questionnaires were disseminated through email or distributed by the Uniquest knowledge integrators (KIs), and some were completed during small meetings.

3. Organizing Knowledge to Provide a Regional Perspective

Existing literature and official statistics from the CT countries and the Food and Agriculture Organization of the United Nations (FAO) were utilized as the basis for describing the situation at the regional level. The work revealed a number of interesting aspects of fish production and trade in the CT6.

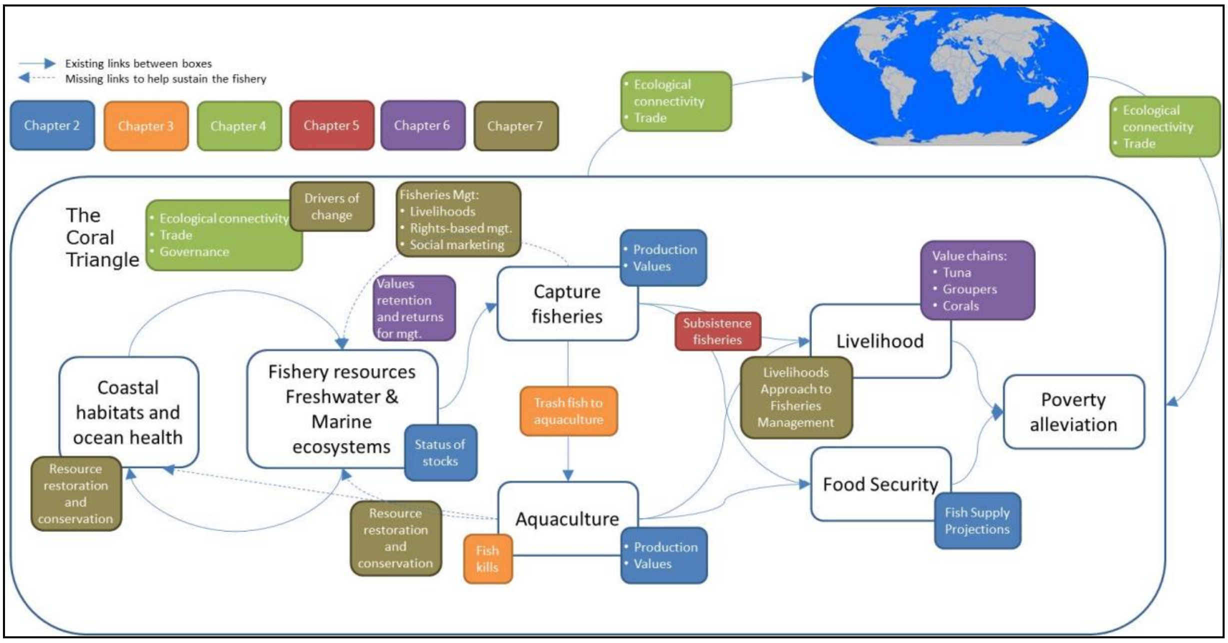
4. Recommending Regional and National Actions

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

C. Organization of the Report

The framework for this study was provided by the interconnections and relationships between fishery resources and their dominant use in the CT. Coastal habitats and ocean health help sustain a diverse and highly productive fishery system in the CT. These wild resources are heavily exploited by most of the CT6. By-catch and wastes from capture fisheries are also used to as feeds in aquaculture farms. Juvenile and small-sized target fishes are grown to market size in cages to increase their value for sale. Products from both capture fisheries and aquaculture are used to increase food security of communities and provide significant sources of livelihood, both of which are important ingredients for poverty alleviation.

The chapters in this report discuss various aspects of this fishery resource chain. The color-coded boxes in the figure below correspond to topics covered in the following chapters and their relevance to parts of the resource chain to elucidate key issues in the management, enhancement, and maintenance of fisheries productivity in the CT region. The solid arrows represent currently established and existing links between boxes in a typical fisheries/aquaculture in the CT6 vis-à-vis outcomes for livelihood, food security, and poverty alleviation. The broken arrows represent missing links that could help sustain the fisheries by internalizing some management costs within the fishery systems. They mainly ensure that the flow of benefits does not go only in one direction (i.e., from resources to people) but also have feedback mechanisms for maintaining and/or enhancing the natural resources that the fisheries depend on (e.g., habitats and fish stocks).



The general approach taken in preparing this report was to first highlight the features of the CT, covering basic socioeconomic parameters, production, and trade in fisheries and aquaculture commodities (**Chapter II).** Statistics from FAO were used and aggregated at the country levels in production volume and value terms for marine capture fisheries and aquaculture to arrive at a CT-wide estimate. Catch composition and CT contribution to global supply of fisheries commodities are discussed, and fisheries contribution to national incomes is presented, with a caveat that in most Pacific countries, both the estimation of fisheries and national accounts may not yield accurate numbers, thereby requiring some re-estimation of figures.

Chapter III focuses on how the RPOA and NPOAs address aquaculture while recognizing its potential contribution to food security. Interactions of aquaculture with capture fisheries are described, confirming the need for the EAFM framework to integrate aquaculture issues. The demand for trash fish as feed is estimated, highlighting 'overheated' aquaculture operations, such as in the Philippines.

In **Chapter IV,** three types of connectivities are analyzed (ecological, economic, and institutional), which justify the establishment of CTI as a regional initiative. More purposeful connections should be established, including trade and institutional alliances, with individual countries serving as nodes or connections. This is supported by observations on the natural associations among the CTI Southeast Asian countries and among the CTI Pacific countries. In terms of economic connectivity, trade occurs more between the CT countries and the global markets than between and among the CT countries.

In **Chapter V,** the grossly undervalued contribution of the subsistence sector to food and household incomes is highlighted, using case studies from the Solomon Islands and Timor-Leste to provide better estimates. An overview of subsistence fisheries is provided, drawing mainly from the literature and emphasizing differences in subsistence fisheries between the Pacific and Southeast Asian CTI countries. In **Chapter VI,** the focus is on trade for tuna, corals, and live reef fish and on estimating value retention at the country level using a value chain approach—one criterion to justify the pursuit of trade. In **Chapter VII,** various fisheries management interventions that have been tested are discussed, South-South learning proposed, and the long-term threats to food security outlined.

Chapter VIII, the concluding chapter, summarizes key messages from the earlier chapters and proposes eight regional courses of action using an economic framework, which 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.

CHAPTER II
FISH PRODUCTION IN THE CORAL TRIANGLE: STATUS, TRENDS, AND CHALLENGES

A. Socioeconomic Profile of the Coral Triangle Countries

Land and Sea Area. The six countries that make up the Coral Triangle cover a total land area of 3.3 million square kilometers (km^2), with Indonesia having the largest land area of 1.9 million km^2 and Timor-Leste having the smallest at 14,900 km^2. Likewise, Indonesia has the longest coastline of 108,800 km and Timor-Leste has the shortest at only around 700 km. In the median range for total land area, Malaysia has 329,800 km^2 and the Philippines, 300,000 km^2. However, the Philippine coastline is longer (37,000 km) than that of Malaysia (4,800 km) and the 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, PNG's land area and population are greater than those of the two other countries 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 countries comprising the CT exhibit a wide range of socioeconomic features. Two sub-clusters are apparent when looking at statistics of the countries: the larger economies of the Southeast Asian countries (CT-SEA), viz., Indonesia, Malaysia, and the Philippines; and the smaller economies of the Pacific Islands (CT-Pacific), viz., PNG, Solomon Islands, and Timor-Leste. Coastal and fishery resources are sources of food and income for the people living in the CT, and are inputs for the allied trade and industrial sectors in the region.

Population and GDP. In 2011, there were more than 373 million people living in the CT6, with the largest population of almost 242 million in Indonesia, and the smallest (500,000) in the Solomon Islands. A third of the population in the CT6 lives within 10 km of the coastline and is most likely dependent on coastal and fishery resources in various ways. Overall, 8% of the CT6 population depends on fisheries and aquaculture for their direct livelihood (**Table 1**). The populations in the CT6 have been growing steadily over the past decades (**Fig. 1**), and from 2007–2011, the population growth rate averaged 1.71%, slightly higher than the global figure for the same period (1.66%).[5] 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 terms of income, Asia and the Pacific have 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 economies, such as the People's Republic of China (PRC), Japan, and India. Real GDP growth was robust for the Pacific economies in the CT, with Timor-Leste growing by more than 10% over a five-year period, followed by PNG (7.3%) and the Solomon Islands (6.8%).[6]

[5] Global population rate data from Worldbank Development Indicators; accessed at http://data.worldbank.org/ data-catalog/world-development-indicators on 28 February 2013.
[6] Source: http://www.adb.org/statistics/

Table 1: Population and Fishing Dependence in the CT6

Key Features	Indonesia	Malaysia	Philippines	PNG	Solomon Islands	Timor-Leste	Total
2011 population (million)[a]	241,600,000	28,990,000	94,185,000	7,000,000	539,852	1,092,109	373,406,961
Land area (km^2)	1,900,000	329,847	460,000	300,000	28,000	14,874	3,032,721
Population density (people/ land area in km^2) (2009)	122	85	307	14	18	70	118
Mean annual population growth rate (%) (last five years, 2007–2011)	1.4	1.8	1.8	2.8	2.3	2.4	1.71
% population living within 10 km of coastline[b]	28	32	47	23	84	53	33
Population living within 10 km of coastline	64,783,600	8,928,000	43,346,502	1,460,040	433,331	551,166	119,502,639
Capture fisheries employment (primary sector)	2,641,566[c]	125,632[f]	1,388,173[g]	120,000	5,114	7,600	4,927,704
Aquaculture employment (primary sector)	2,493,193[d]		226,195				2,719,388
% population dependent on fisheries and aquaculture [e]	8.9	1.8	7.0	9.5	5.0[h]	3.7	7.8

a ADB. 2011. *Key indicators for Asia and the Pacific*. Accessed at www.adb.org/statistics

b Center for International Earth Science Information Network (CIESIN). National Aggregates of Geospatial Data: Population, Landscape and Climate Estimates, v.2 (PLACE II), Palisades, NY: CIESIN, Columbia University; 2007.

c Secondary sector estimated employment at 1,164,178 in 2005 (http://www.fao.org/fishery/countrysector/FI-CP_ID/en)

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

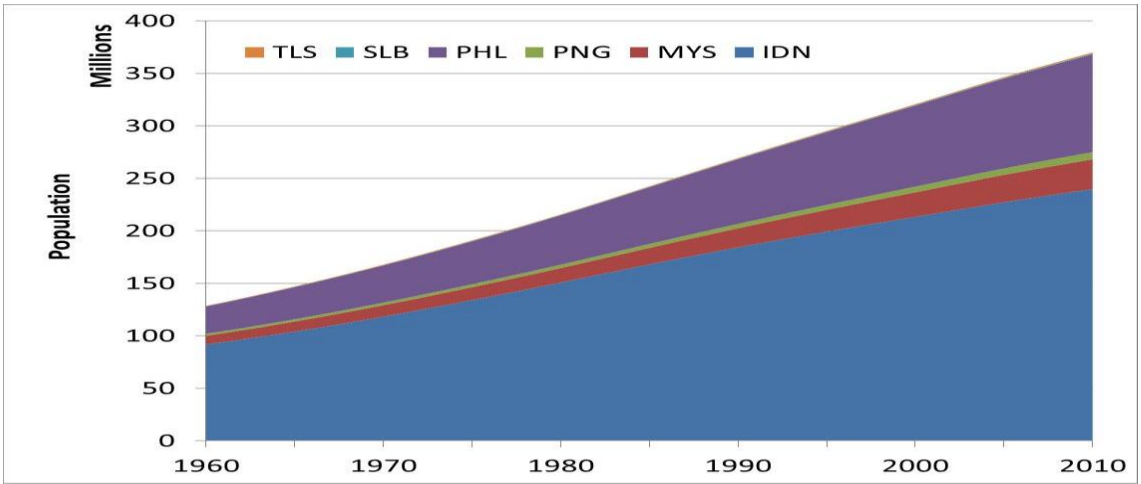
e Assuming four members per household on average for Philippines, Malaysia, and Indonesia and five members per household for Papua New Guinea, Solomon Islands, and Timor-Leste.

f Number of fishers working on licensed fishing vessels (2009).

g 1,371,676 are municipal fishers and 16,497 are commercial fishing operators. Source: http://www.bfar.da.gov.ph/pages/aboutus/maintabs/stat-fishcontri.html

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

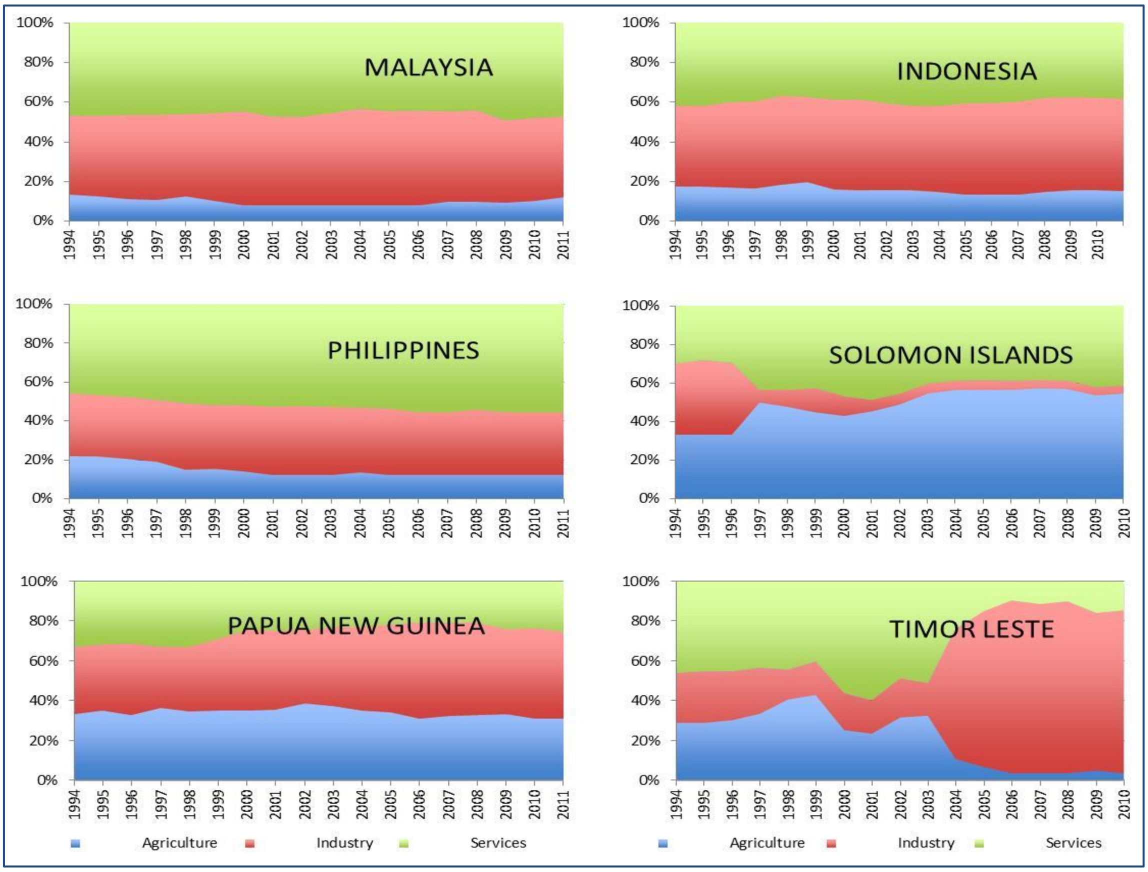
Figure 1: Population Trends in the CT6



Source: http://data.worldbank.org/indicator/SP.POP.TOTL; accessed on 25 October 2012.

The share of agriculture (including fisheries and aquaculture) in GDP declined in the CT-SEA countries (**Fig. 2**) as the economies were dominated by the services and industrial sectors. In the Solomon Islands, the share of agriculture in GDP increased from 30% in 1994 to more than 50% in 2011, with the service 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 industrial sector, mainly petroleum and accounting for more than 80% of GDP, has buoyed the economy of Timor-Leste 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 further boost revenues from the industrial sector, but concerns regarding increasing income disparity due to inability to translate revenues into basic social and physical services remain.

Figure 2: GDP Composition in the CT6



Malaysia is moving towards joining the ranks of the high-income economies. This will increase 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 (BOT) deficit of about $1.75 billion in 2004 (Musa, 2005). The *Third National Agricultural Policy (NAP) 3 (1998–2010)* was expected to provide a facelift to the country's agricultural sector and recognize the significant contribution of the fisheries sector to the economy. Based on data from the Ministry of Agriculture (2004), 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 the production of the fisheries sector and ensure its contribution to food security, exports, improved incomes, and poverty alleviation.

Poverty incidence in PNG, the Philippines, and the Solomon Islands was between 20–30%. In 2008, it was more than 41.1% In Timor-Leste, in sharp contrast to Malaysia's 3.8%. In the Pacific, there has been "urbanization of poverty" (ADB, 2012). The previous definition of poverty as equivalent to "hardship" has been replaced by the harsh reality of hunger, destitution, and absolute poverty, as is experienced in other developing countries, due mainly to 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-Pacific population lived in urban areas, the second lowest urban proportion of a region in the world. However, in the last two decades, 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, Malaysia has the largest urban population (72%) and PNG has the lowest (12%). The fastest rural to urban migration trends are observed in the Solomon Islands and Timor-Leste.

B. Fisheries Production in the Coral Triangle[7]

Fish supply in the Coral Triangle is obtained from two primary sources: capture fisheries and aquaculture. **Capture fisheries** are often divided into two categories based on the size of vessels used and the volume of fishes caught per unit effort: (i) large-scale, industrial, or commercial fisheries; and (ii) small-scale or artisanal fisheries.[8] **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 termed a **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, fishpen, or fishcage. Farming of aquatic plants is done without the use of confinement systems.

In 2010, the CT6 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 tons of these were for food (i.e., fish and invertebrates) while the remaining 6 million tons were aquatic plants, which are high-value products contributing to the income of aquaculture workers and owners. Excluding aquatic plants, the CT6 contributed 9.8% to global food supply from aquatic sources in 2010.[9]

Table 2: Aggregate Aquatic Production (t) of the CT6, 2010

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 FishStat J.*

Most fisheries production in the CT6 comes from the marine and brackishwater environment with a production of 10.8 million t of fish and invertebrates in 2010 compared to on 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 imports food fish and related commodities from other countries. In 2010, the CT6 imported an aggregate volume of 802,461 t of fishery commodities.[10] Fishery trade patterns are discussed in greater detail in Chapter 3.

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7 Time-series information on the volume (t) of marine capture fisheries production and the volume (t) and value ($) of aquaculture production for the six countries was 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 molluscs) and aquaculture (freshwater environment, inland waters, freshwater fishes, freshwater crustaceans, and freshwater molluscs). Source: FAO Fisheries and Aquaculture Department, Statistics and Information Service. *FishStatJ: Universal software for fishery statistical time series*. Copyright 2011. http://www.fao.org/fishery/statistics/software/fishstatj/en

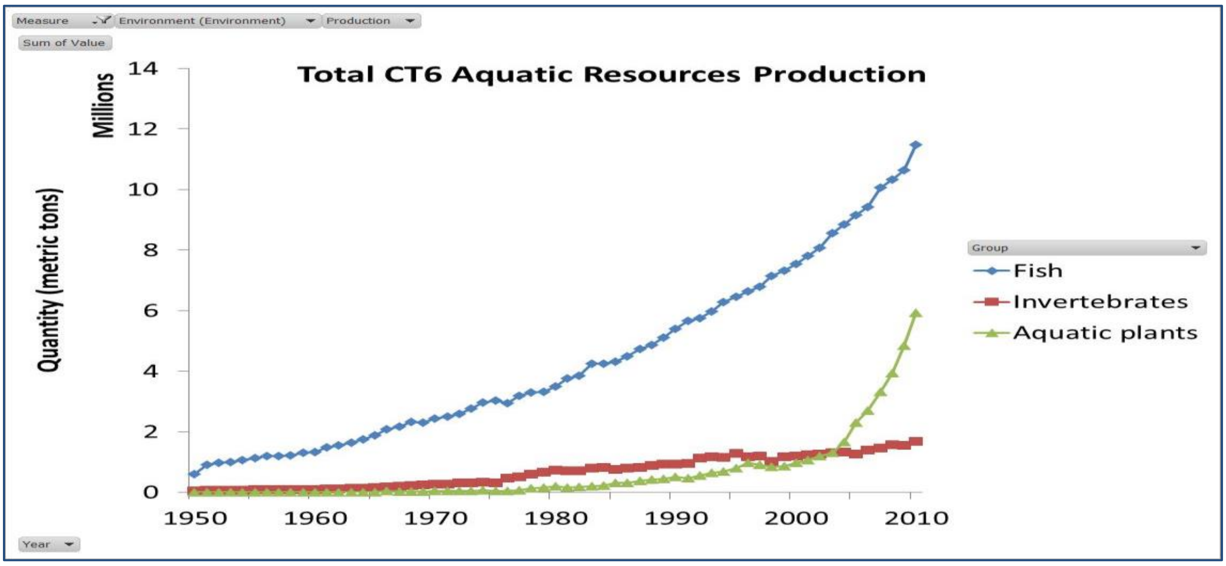
8 http://www.fao.org/fishery/topic/12306/en

9 Global production of fish and invertebrates in 2010 was 134,386,512 t based on the FAO FishStatJ software.

10 Global population data from World Bank Development Indicators. http: //data.worldbank.org/data:catalog/world-development-indicators. Accessed on 28 February 2013.

Overall, fisheries production in the CT6 continues to grow (**Fig. 3**). Fish 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 is growing at a modest rate of 7% per year.

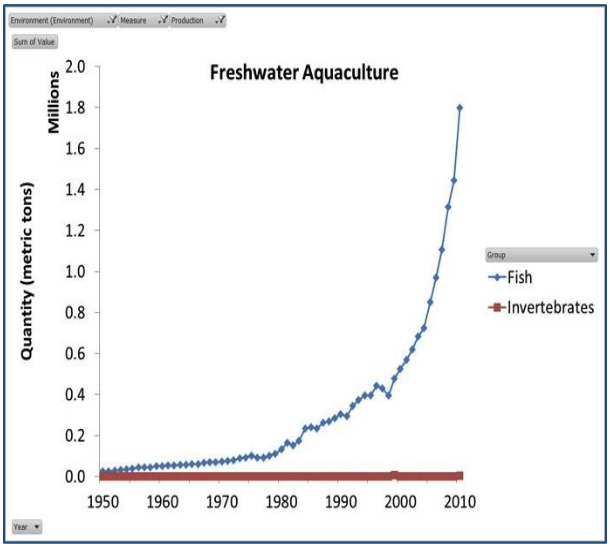
Figure 3: Total Aquatic Resources Production from 1950–2012 in the CT6

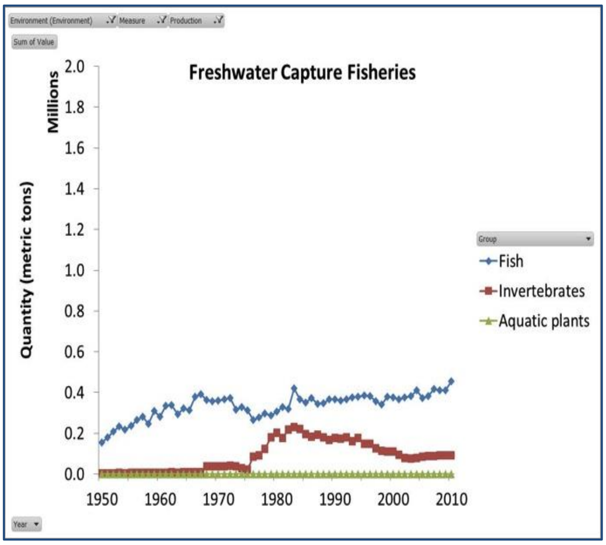


Source*: FAO FishStatJ*

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

Figure 4: Trend in Aquaculture and Capture Fisheries Production from Freshwater/Inland Environments in the CT6





Source: *FAO FishStatJ.*

The continued growth in fisheries and aquaculture production from marine and brackishwater environments in the CT6 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 seaweeds, shrimps, and milkfish are the major marine and brackishwater aquaculture commodities in the CT6.

Table 3: Major Fishery Resources and Aquaculture Products of the CT6

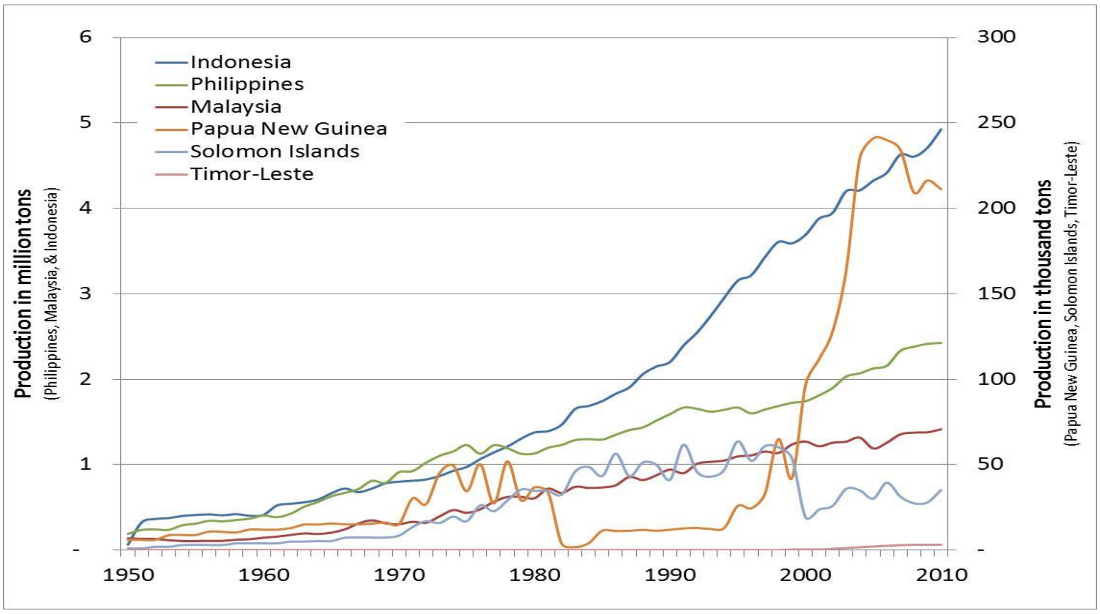
Country	Major Marine Fishery Resources (by volume)	Major Marine and Brackishwater Aquaculture Products
Indonesia	1. Large pelagics (skipjack [*Katsuwonus pelamis*], other tunas, billfish, oceanic sharks and small tuna) 2. Small pelagics (scads, mackerels, sardinellas, trevallies, engraulid anchovy) 3. Demersal and coral reef fishes (groupers, snappers, rabbitfish, slipmouth, etc.) 4. Prawn, shrimp, other crustaceans, etc.	1. Seaweed 2. Shrimps 3. Milkfish (*Chanos chanos*) 4. Giant gourami 5. Grouper 6. Mud crab
Malaysia[a]	1. Small pelagics: Indian mackerel (*Rastrelliger* spp.), roundscad (*Decapterus* spp.), squids (*Loligo* spp.), anchovies (*Stolephorus* spp.), ox-eye scad (*Selar boops*), hardtail scad (*Megalaspis cordyla*), lizardfish, 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. Shrimp/prawns (Hawaiian white shrimp and tiger prawn) 4. Barramundi 5. Mussels
Philippines	1. Small pelagics (roundscads (Decapterus spp., Carangidae), anchovies (*Stolephorus* spp., Engraulidae), sardines (*Sardinella* spp., Clupeidae) and mackerels (*Rastrelliger* spp., Scombridae); round herrings (Clupeidae), flying fishes (Exocoetidae), and halfbeaks (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: slipmouths, spadefishes, groupers and catfishes; snappers and rabbitfish; marine ornamental fishes 4. invertebrates: crabs (e.g., *Portunus pelagicus*)	1. Seaweed (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., groupers)
Papua New Guinea	1. Tuna: albacore and yellowfin 2. Shrimp: banana prawn (*Penaeus merguiensis*) 3. Reef fishes: wrasse (Labridae), groupers (Serranidae), emperors (Lethrinidae), bream (Sparidae), sea perch and fusiliers (Lutjanidae), parrotfish (Scaridae), sweetlips (Haemulidae), butterflybream and monocle bream (Nemipteridae), squirrelfish (Holocentridae), drummers (Kyphosidae), eels (Muraenidae), triggerfish (Balistidae), rabbitfish (Siganidae), surgeonfish and unicornfish (Acanthuridae) and goatfish (Mullidae) 4. Invertebrates: bêche-de-mer, lobsters, trochus, giant clams, crabs, octopus, and green snail	Marine and brackishwater aquaculture in PNG is not extensive. Some of the marine aquaculture products are seaweeds, giant clams, crocodile, milkfish, mullet, mussels, oysters, and prawns
Solomon Islands	1. Tuna: skipjack, yellowfin, bigeye, albacore 2. Pelagics: sharks, billfish, opah, wahoo, dolphinfish 3. Demersal and reef fishes: Lutjanidae (snappers), Serranidae (groupers and rock cods), Lethrinidae (emperors), Scombridae (mackerels), Carangidae (trevallies) 4. Invertebrates: bêche-de-mer, trochus, green snail, and giant clams, crabs, and lobsters	Priority aquaculture commodities are seaweeds, 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 *Country Profiles.*

1. Marine Capture Fisheries in the Coral Triangle

Production Volumes and Trends. In 2010, a total of 9 million t of fish and invertebrates were harvested by capture fisheries from the coastal and marine waters of the CT6, accounting for 11.8% of global capture fisheries production in that year. Indonesia and the Philippines accounted for 54% and 26% of this production, respectively (**Fig. 5**), while Timor-Leste had the lowest marine capture fisheries production at 3,125 t. While global capture fisheries production appears to have leveled off since 1986 at 80 million t, CT6 capture fisheries production continues to rise although the rate of growth has slowed down in the last decade from an average annual growth rate of 4.8% in 1951–1999 to 2.8% in 2000–2009 (**Fig. 5**). Indonesia continues to lead the CT6 in terms of growth in capture fisheries production followed by the Philippines, Malaysia, PNG, and Timor-Leste. FAO time-series catch data for Solomon Islands indicate a sharp decline from 1999 to 2000 by as much as two-thirds, which has been attributed to ethnic tensions that began in the 1990s (Pinca *et al*., 2009). From 2000, capture fisheries production of the Solomon Islands has fluctuated around 30,000 t.

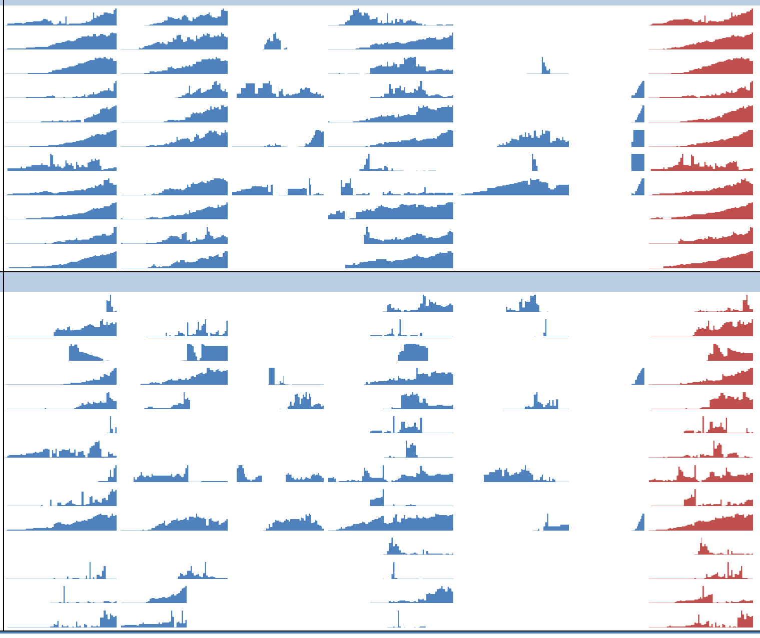
Figure 5: Estimated Marine Capture Fisheries Production in the CT6, 1950–2010



The secondary vertical axis (right) corresponds to data for PNG, Solomon Islands, and Timor-Leste. Data for Solomon Islands and PNG exclude catches from foreign-based fleets which, in 2007, contributed 52.8% and 70.1% to the total capture fisheries production of PNG (619,568 t) and Solomon Islands (139,892 t), respectively (Gillett, 2009).

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

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



ISSCAAP Group Species	INDONESIA	MALAYSIA	PAPUA NEW GUINEA	PHILIPPINES	SOLOMON ISLANDS	TIMOR LESTE	CORAL TRIANGLE	CT (Tons; 2009)
Marine fishes								
Flounders, halibuts, soles								36,741
Herrings, sardines, anchovies								1,192,838
Sharks, rays, chimaeras								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-spiders								112,734
Sea-urchins and other echinoderms								5,338
Mussels								549
Oysters								418
Pearls, mother-of-pearl, 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 molluscs								3,060

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

Tuna is an important fishery commodity in the CT as evidenced by the aggregate catch composition of the CT6 fisheries. In 2009, 46% of all tuna catches in the Western and Central Pacific (WCP), valued at $1.5 billion, came from the national waters of Indonesia, Philippines, PNG, and Solomon Islands (**Table 5**). Of this amount, $1.1 billion is retained in the CT countries (excluding access for foreign fishing fleets in PNG and the Solomon Islands). For both PNG and Solomon Islands, tuna catches by foreign fleets were higher than by the respective national fleets. The Philippine fleet, however, is able to fish in other waters of the WCP as its total catch exceeds those caught in its national waters. Tuna data from the *Western and Central Pacific Fisheries Commission* (*WCPFC*) for the Solomon Islands indicate a relatively stable annual catch of around 84,000 tons from 1997–2009.[11]

Table 5: Tuna Catches in the Western and Central Pacific, 2009

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

*n.a. = not applicable.

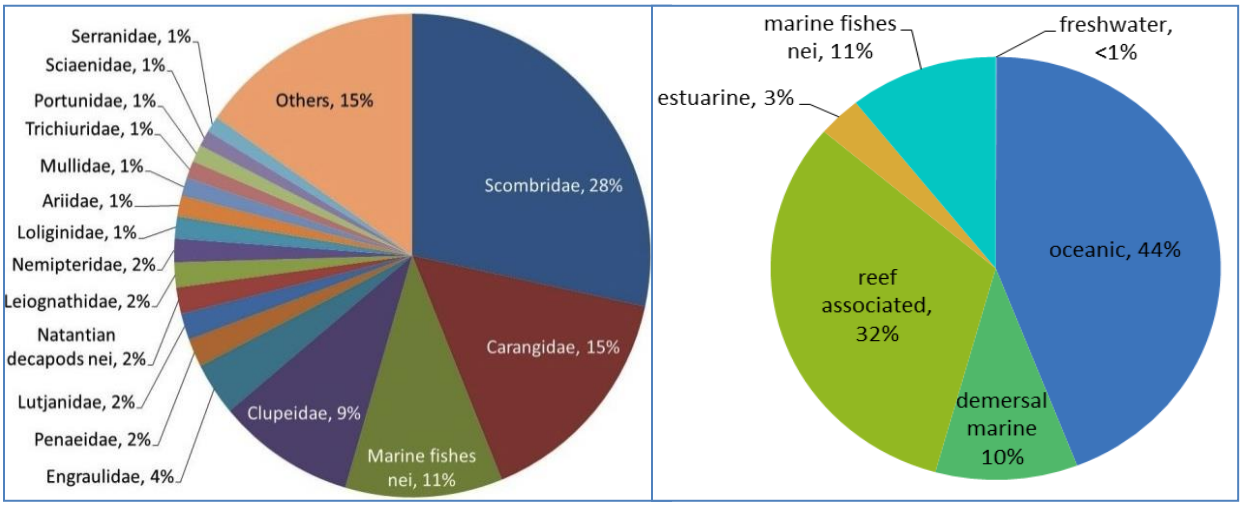
[a] Others include Fisheries Forum Agency (FFA) members: Australia, Cook Islands, Fiji, Federated States of Micronesia, Kiribati, Marshall Islands, Nauru, New Zealand, Niue, Palau, Samoa, Tokelau, Tonga, Tuvalu, Vanuatu, and other countries and territories fishing for tuna in the Western and Central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

Source: http://www.ffa.int/catch_value

[11] http://www.ffa.int/catch_value

Catch Composition. Open water pelagic fishes from the families Scombridae, Carangidae, and Clupeidae comprised 53% of the total marine capture fisheries production for the CT6 in 2009 (**Fig. 6**). A large part of the reported catch is not disaggregated into fish families (i.e., marine fishes not elsewhere identified or 'nei' made up 11% of capture fisheries production in 2009). Mackerels, especially the short mackerel (*Rastrelliger brachysoma*) and Indian mackerel (*Rastrelliger karnagurta*), and tuna (skipjack, frigate, and yellowfin) form the bulk of the catches in the CT6, accounting for half of the marine capture fisheries production of Indonesia and the Philippines (SEAFDEC, 2012). Of the fish caught in the CT6 in 2009, 32% or 2.78 million t comprised reef-associated fish and invertebrate families (**Fig. 6**).[12] Of these reef-associated fish 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 beds or forage in these areas, as identified in the online fish database, FishBase.[13] The total volume of reef-associated fishes and invertebrates would most likely increase considerably if subsistence fisheries were taken into account and general "nei" categories further disaggregated in landing reports and statistics.

Figure 6: Aggregate Marine Fish Catch Composition in the CT6, 2009



Note: Left: using Aquatic Sciences and Fisheries Information System (ASFIS) family classification; right based on habitat/ ecosystem association of catches.
Source: *FAO FishStatJ*; habitat/ecosystem

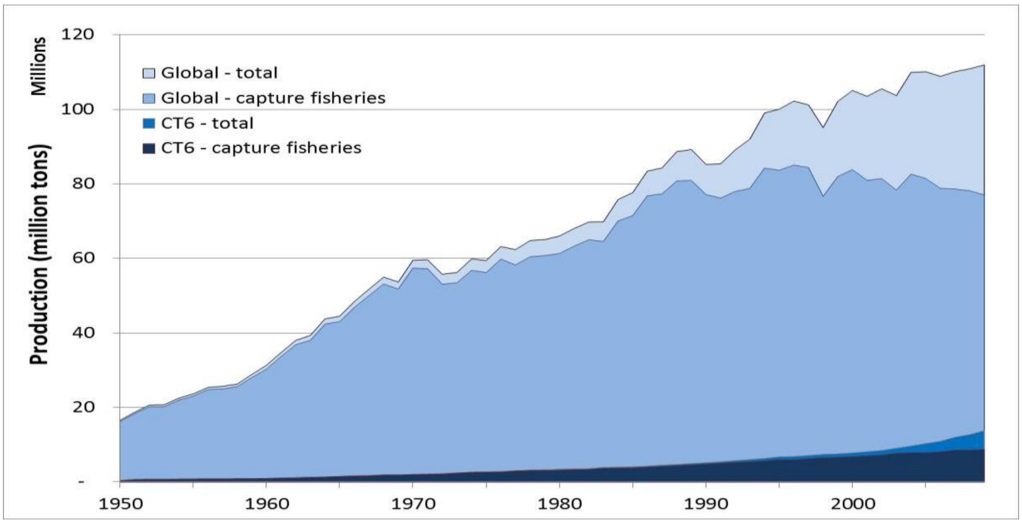
One of the unique features of the fisheries of CT6 is the diversity of marine fishery resources that are extracted, consumed locally, processed, and exported. More than 2,500 species of reef-associated fish can be found in the CT, a large number of which are exploited for sale or subsistence. Reef, mangrove, and seagrass-associated fishes are targeted by subsistence and small-scale fishers and 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 CT countries, limited primarily by technological capability (Barut *et al*., 2004).

Foreign-based Fleet Catches. Reported catches in FAO data for PNG and the Solomon Islands are underestimates since they do not include catches by foreign-based fleets. Gillett (2009) estimated that in 2007, catches by foreign-based fishing fleets for PNG and Solomon Islands added 327,471 t and 98,023 t , equivalent to 112% and 234% of total domestic marine catches for the two countries, respectively. Using the same proportions, the 2010 catches from PNG and Solomon Islands would be at least 447,907 t and 117,558 t, respectively, bringing the total marine capture fisheries production for the CT to 9.3 million t.

[12] FAO landing data were categorized according to source ecosystem as per the method of Newton and colleagues (2007). The list of FAO landing groups and corresponding habitat/ecosystem category used for this analysis is in **Appendix 1**.
[13] http://www.fishbase.org/

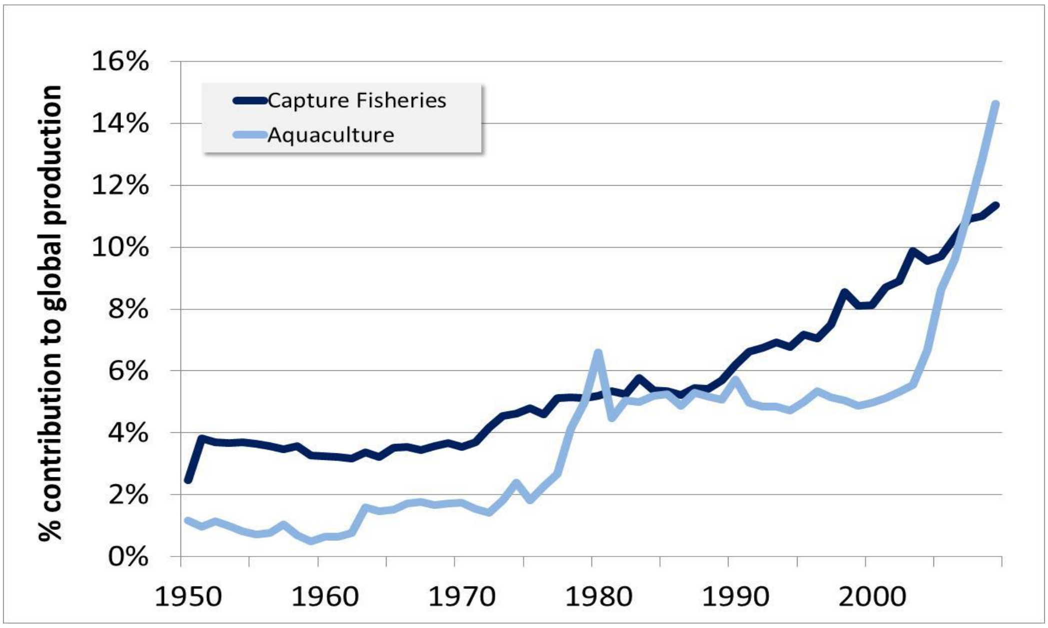
Contribution of CT6 Marine Capture Fisheries to Global Fish Production. The contribution of the CT6 to global fish production has been increasing since 1950, with an annual growth rate of 5.1% from 1953–2003 and 7.1% from 2004–2009 (FAO, 2009) (**Figs. 7 and 8**). In 2009, the CT6 contributed 12.4% (13.8 million t) to global marine fisheries production. Using FAO data, capture fisheries from the CT6 accounted for 11% (8.74 million t) of global catches while aquaculture production contributed 14% (5.10 million t) to global aquaculture production. These production values are most likely underestimates because illegal, unreported, and unregulated fishing has not yet been fully included in statistics. Catches of foreign-based fishing fleets are also not included in the CT6 fish production statistics.

Figure 7: Total Global Marine Fisheries Production and Production by the CT6



Source: *FAO FishStatJ*.

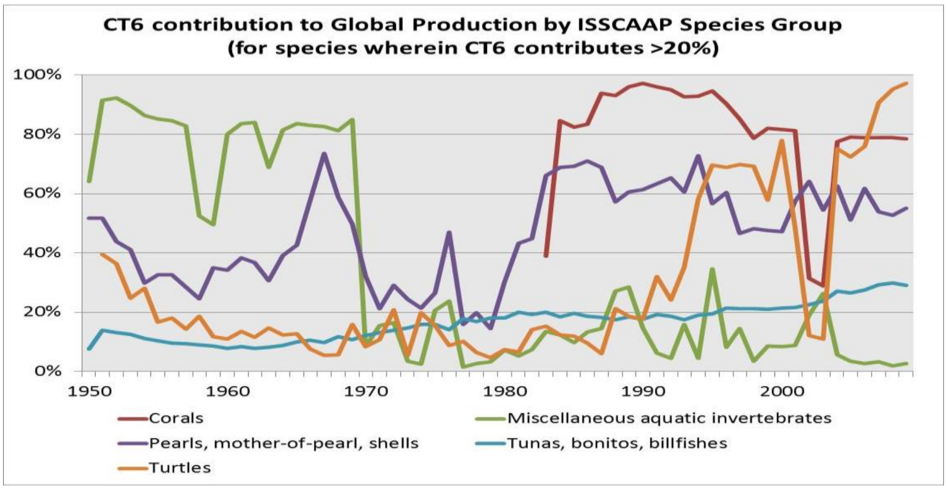
Figure 8: Percentage Contribution of CT6 to Global Fish Production



Source: *FAO FishStatJ*.

Based on FAO statistics, the major contribution of the CT6 to global fish production consists of corals; turtles; pearls, mother-of-pearls, and shells; and tunas, bonitos, and billfishes (**Fig. 9**). Coral harvests from the CT6 amount to 4,000 t, accounting for 80% of reported global harvests of corals based on the FAO dataset for 2009. Turtle catches by the CT6 have been rising and, in 2009, more than 90% of the FAO-reported 248 t of turtles came from the CT6.[14] The CT6 also produced 55% of the 7,753 t of global production of the ISSCAAP 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 the CT6.

Figure 9: Fishery Resources of the CT6 Contribute more than 20% of Global Supply

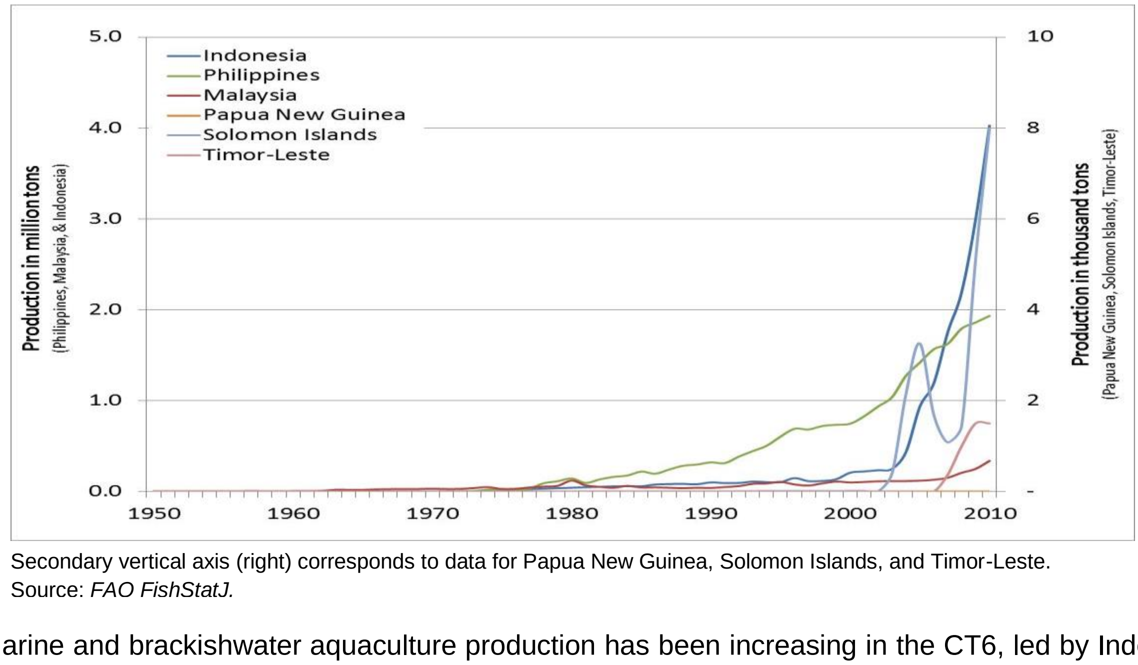


Source: *FAO FishStatJ.*

2. Marine and Brackishwater Aquaculture in the Coral Triangle

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

Figure 10: Estimated Marine and Brackishwater Aquaculture Production in the CT6, 1950–2010



Secondary vertical axis (right) corresponds to data for Papua New Guinea, Solomon Islands, and Timor-Leste.
Source: *FAO FishStatJ.*

Marine and brackishwater aquaculture production has been increasing in the CT6, led by Indonesia, where production has expanded at a remarkable rate of 400,000 t/yr, on average (Fig. 10). From 2003–2010, 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

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

have shown a slower growth in aquaculture production growth. For example, Malaysia's marine and brackishwater aquaculture production grew by 24,000 t/yr, as compared to the Philippines' 112,000 t/yr. Mariculture in the other CT6 countries is also still in the development stage,[15] although FAO data include some mariculture production in the Solomon Islands and Timor-Leste but none in PNG.

Aquaculture Commodities. Seaweeds comprise the bulk (95%) of marine and brackishwater aquaculture production in the CT6, with the rest comprising of milkfish, mussels, and oysters (**Table 6**). Growout 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.

Table 6: Composition of CT6 Marine and Brackishwater Aquaculture Production

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-pearl, 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-urchins and other echinoderms	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 seaweeds	3,915,017	207,892		1,796,963	8,000	1,500	5,929,372	8,973,565
Green seaweeds				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**

Source: *FAO FishStatJ*.

Contribution of CT6 Marine and Brackishwater Aquaculture to Global Fish Production. Indonesia and the Philippines were among the Top 10 world aquaculture producers by volume in 2010, accounting for 3.85% and 1.24%, respectively, of the 59.9 million t of global aquaculture production (including freshwater aquaculture) (FAO, 2012). Excluding freshwater aquaculture, the CT6 contributed 17% of global production from marine and brackishwater aquaculture in 2009. If production from China is excluded, the proportion from the CT6 would be 45% of world aquaculture production.

The CT6 aquaculture industry produces 96% of pearls, mother-of-pearls, shells, 66% of the world's red seaweeds (*Eucheuma cottonii*), 25% of lobsters and spiny-rock lobsters, and 20% of green seaweeds (e.g., *Caulerpa* species). Although about two-thirds (63%) of total marine fisheries production in the CT6 comes from capture fisheries, aquaculture production in the CT6 could surpass capture fisheries production by 2017, based on the 24.2% annual increase in aquaculture from 2004–2009 compared to the 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 the six countries (**Tables 7–9**). For capture fisheries, the derived price clearly supports a *Southeast Asia vs. a Pacific grouping* based on the convergence of prices. Fishes are generally more expensive by at least 50% in the Pacific compared to Southeast Asia. In contrast, the

[15] See also Chapter III.

derived prices from aquaculture are more dispersed, with Indonesia and the Philippines registering the lowest prices, possibly because seaweeds comprise the bulk of the 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 7: Volume and Value of Capture Fisheries Production, 2007

Country	Volume (t) (FAO)[1]	Volume (t) (Various Sources)	Value ($)	Value/ton ($)
Indonesia	4,630,588	4,734,280[2]	4,931,010,735[2]	1,042
Malaysia	1,355,956	1,381,423[3]	1,466,371,836[3]	1,061
Philippines	2,332,788	2,328,200[4]	2,454,965,353[4]	1,054
Papua New Guinea	234,368	619,568[5]	811,730,952[5]	1,310
Solomon Islands	31,322	139,892[5]	210,079,814[5]	1,502
Timor-Leste	2,912	2,909[6]	5,817,600[6]	2,000[7]
Total	**8,587,934**	**9,206,272**	**9,879,976,290**	**(Mean) 1,328**

[1] Data from FAO FishStatJ .
[2] Source: *Database of Existing Condition on Indonesian Marine and Fisheries*. Accessed at http://www.kkp.go.id/upload/ jica/ web01/index.html on 25 October 2012.
[3] Source: *Status of the Fisheries Sector in Malaysia*, 2007. Accessed at http://www.dof.gov.my/224 on 25 October 2012.
[4] Includes: commercial and municipal (marine) fisheries production. Source: http://www.bfar.da.gov.ph/pages/statistics/ table1.htm#table-2. Accessed on 25 October 2012.
[5] Gillett, 2009.
[6] Kalis, O.H. 2010. *Timor-Leste Fisheries: Perspectives on Coastal Community Fishing Activity.* Prepared for Transboundary Diagnostic Analysis-ATSEF Programme (Fisheries and Socioeconomic Profile). Ministry of Agriculture and Fisheries - National Directorate of Fisheries and Aquaculture.
[7] 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).
Sources: *FAO FishStatJ* and various in-country reports and sources.

Table 8: Production and Value from Marine and Brackishwater Aquaculture, 2007

Countries	Volume (t) (FAO)[1]	Volume (t) (Various Sources)	Value ($)	Value/ton ($)
Indonesia	1,752,435	1,509,528[2]	441,959,865[2]	293
Malaysia	152,768	198,450[3]	303,732,907[3]	1,531
Philippines	1,626,193	1,880,100[4]	980,166,358[5]	521
Papua New Guinea	1	200[6]	690,036[6]	3,450
Solomon Islands	1,081	165[6]	33,831[6]	205
Timor-Leste	370	No data[7]	No data[7]	---
Total	**3,532,848**	**3,588,443**	**1,726,582,996**	**1,200 (Mean)**

[1] Data from FAO FishStatJ software
[2] Source: *Database of Existing Condition on Indonesian Marine and Fisheries.* Accessed at http://www.kkp.go.id/upload/jica/ web01/index.html on 25 October 2012
[3] Source: *Status of the Fisheries Sector in Malaysia*, 2007. Accessed at http://www.dof.gov.my/224 on 25 October 2012.
[4] Includes: brackishwater fishpond, marine fishcage/pen, and seaweeds. Source: http://www.bfar.da.gov.ph/pages/statistics/ table1.htm#table-1. Accessed on 25 October 2012.
[5] Includes: brackishwater fishpond, marine fishcage/pen, and seaweeds. Source: http://www.bfar.da.gov.ph/pages/statistics/ table3.htm. Accessed on 25 October 2012:
[6] Gillett *et al*. 2009. For Solomon Islands, the reported tonnage and value ($) is for seaweeds only. Other aquaculture products are recorded as number of pieces and not by volume (i.e., 1,202 pcs of postlarvae capture and/or culture valued at SI$7,554 and 7,000 pcs corals valued at SI$56,000).
[7] Although the Timor-Leste MAF-NDFA (2012) reported the value for seaweeds at $19,130 in 2009, no volume was reported.

Table 9: Currency Conversion Rates, 2007

Currency	$1.00 Equivalent
Indonesian Rupiah (RI)	9,131.12
Malaysian Ringgit (RM)	3.44
Philippine Peso (PhP)	46.09
Papua New Guinea Kina (KI)	2.90
Solomon Islands Dollar (SI$)	7.30

Source: Period average. http://www.oanda.com/currency/ historical-rates; accessed on 25 October 2012.

C. Fisheries Values

1. Contribution of Fisheries to the National Economy of the CT6

The contribution of fisheries and aquaculture to the national economy of the CT6, in terms of the value-added percentage of GDP, percentage of export value of fishery products over total export value, and employment, varies across the CT6. Fisheries and aquaculture comprise between 1.2–6.8% of GDP (**Table 10**).

Table 10: Estimated Contribution of Fisheries to the National Economies of the CT6 in terms of GDP, Exports, and Employment

Country	Fisheries as % of GDP (2007)	% Export Value of Fishery Products of All Exports	Employment	
			Fisheries	Aquaculture
Indonesia	2.4[1]	1.9[5]	2,169,279[8]	749,441[8]
Malaysia	1.2[2]	0.4[6]	99,617[9]	no data
Philippines	2.2[3]	0.9[7]	1,388,173[10]	226,195[10]
Papua New Guinea	3.4[4]	10.0[4]	5,114	no data
Solomon Islands	6.8[4]	12.0[4]	30,000	no data
Timor-Leste	no data	no data	5,718	no data

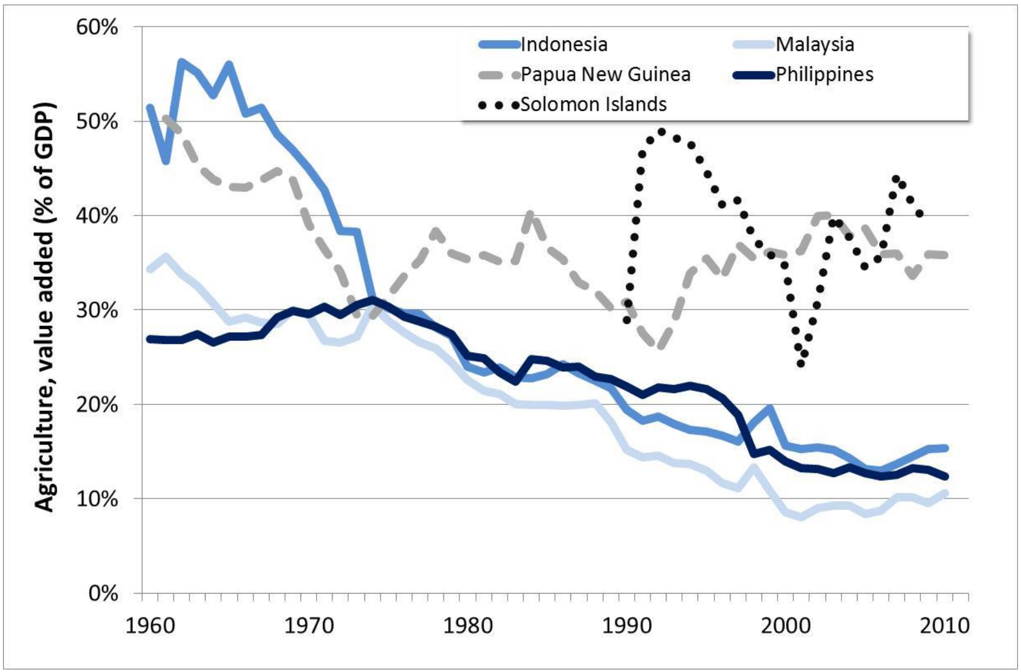
[1] Source: *Database of Existing Condition on Indonesian Marine and Fisheries.* http://www.kkp.go.id/upload/jica/web01/index.html; accessed on 25 October 2012.
[2] Source: *Status of the Fisheries Sector in Malaysia*, 2007. http://www.dof.gov.my/224. Accessed on 25 October 2012.
[3] Source: *Philippine Fisheries Profile, 2007*
[4] Gillett, 2009.
[5] http://www.kemendag.go.id/statistik_perkembangan_impor_nonmigas_%28komoditi%29/. Accessed on 25 October 2012.
[6] Obtained by dividing the total fish export value for Malaysia for 2007 by the total export value of Malaysian commodities (2007). Source: 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 on 25 October 2012.
[7] http://dti.gov.ph/uploads/DownloadableForms/BETP%20Stats_Exports%20by520Product%20Grouping%20FY%202006% 20to%202011_25may2012.pdf. Accessed on 25 October 2012.
[8] Data for 2009 from *Indonesian Fisheries Book*, 2011.
[9] *Status of the Fisheries Sector in Malaysia*, 2009.
[10] Data from DA-BFAR for 2002. 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 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/planning agencies affect the credibility of the numbers. Gillett and Lightfoot (2001) re-estimated 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 ot GDP for the 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, etc.). Accounting for indirect and induced effects, the contribution of the fisheries sector to the national economies of the CT6 could double or triple the current estimates, which use only the value of landings at first sale (e.g., Dyck and Sumaila, 2010). The contribution of the subsistence sector to the national economy is also largely ignored.

In the past half century, the percent contribution of agriculture (including fisheries) to the GDP of Indonesia, Malaysia, and the Philippines has been declining to an almost stable level of 10%–15% (**Fig. 11**). It has remained high for PNG and the Solomon Islands at 35–40% of GDP.

Figure 11: Value-added Contribution of Agriculture to GDP of the CT6, 1960–2010



Source: http://data.worldbank.org/indicator/NV.AGR.TOTL.ZS?page=1. Accessed on 25 October 2012.

Fisheries and aquaculture employ at least 4.6 million citizens of the CT6, representing 1.27% of the aggregate CT6 population or 2.04% of total persons employed in the CT6 in 2009.[16] Assuming an average household size of four, the total number of people directly dependent on fisheries in the Coral Triangle for livelihood is 18.4 million or 5% of the aggregate population of the CT6 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 a variety of ecosystem functions, goods, and services (Hoegh-Guldberg *et al*., 2009). Coral reefs and their associated ecosystems are critical in providing food and livelihood to over 120 million people in the region. Hoegh-Guldberg *et al*. (2009) estimated the value of commercial fisheries at over $3 billion per year in the CT6. This value is less than one-third the actual capture fisheries production value from the CT6 calculated above.

In 2007, the marine capture fisheries of the CT6 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 CT 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 CT was estimated by identifying reef-associated fish catches in the FAO dataset (2007), determining the percentage composition of reef-associated fishes in the total capture fisheries production for each country, and 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**).

[16] Total population for the CT6 in 2009 was 365,394,353; 62.14% of these were employed (15 years and older). Data from the World Bank. Employment to population ratio. http://data.worldbank.org/indicator/ SL. EMP. TOTL. SP.ZS; population data from http://data.worldbank.org/indicator/SP.POP.TOTL.

Table 11: Value of Fisheries Attributed to Coral Reefs, 2007

Country	% Volume of Reef-associated Fish in Production (FAO, 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
Philippines	38	2,454,965,353	932,886,834
Papua New Guinea	1*	811,730,952	8,117,310
Solomon Islands	32*	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**

* Following Newton *et al*. (2007), "marine fishes nei" for Papua New Guinea (0.89% in 2007) and Solomon Islands (31.93% in 2007) were categorized as reef-derived and applied similarly in this study.
Source: Based on catch composition reported in FAO 2007 data.

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

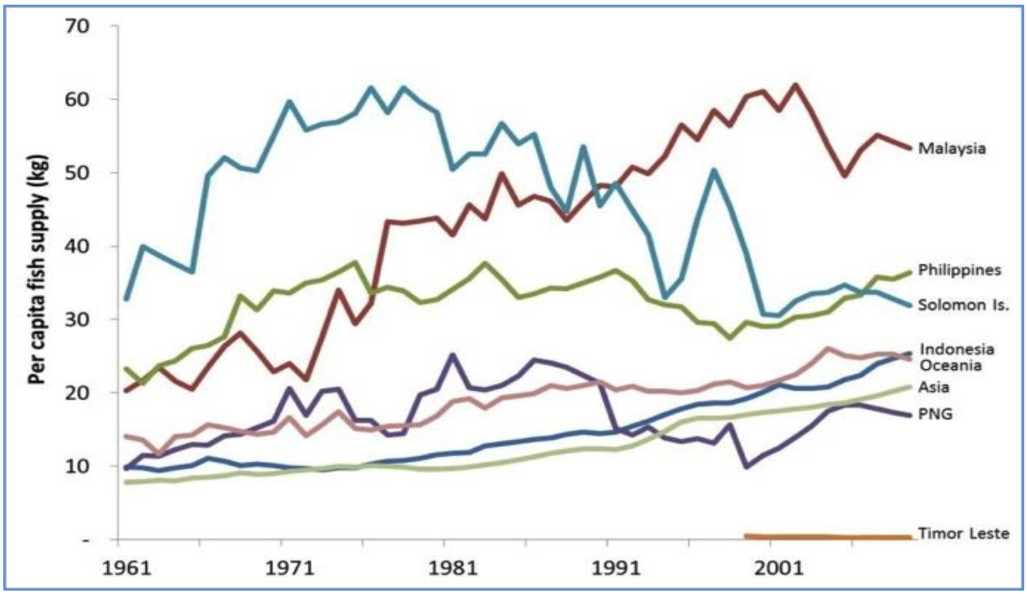
The percentage of reef-associated fishes in overall capture fisheries production varied across the CT6 (**Table 11**). In the CT-SEA countries, reef-associated fishes comprise about 30% of marine capture fisheries production. In the CT-Pacific countries, it is only in the Solomon Islands where reef-associated fishes are reported in FAO landings after the "marine fishes nei" group were interpreted as reef-derived (Newton *et al*., 2007). However, the dominance of tuna in the CT-Pacific's marine fish catches means that the contribution of reefs to capture fisheries production is most likely proportionately smaller than in the CT-SEA. In all the countries, the contribution 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 the CT6. 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 samplings, 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 the CT6 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 and colleagues (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 ecosystems to tuna is estimated to be $150 million for the CT6 (based on values in Table 5), bringing the total value of coral reefs to fisheries in the CT6 to $3.15 billion in 2007.

3. Societal Dependence on Fish and Food Consumption

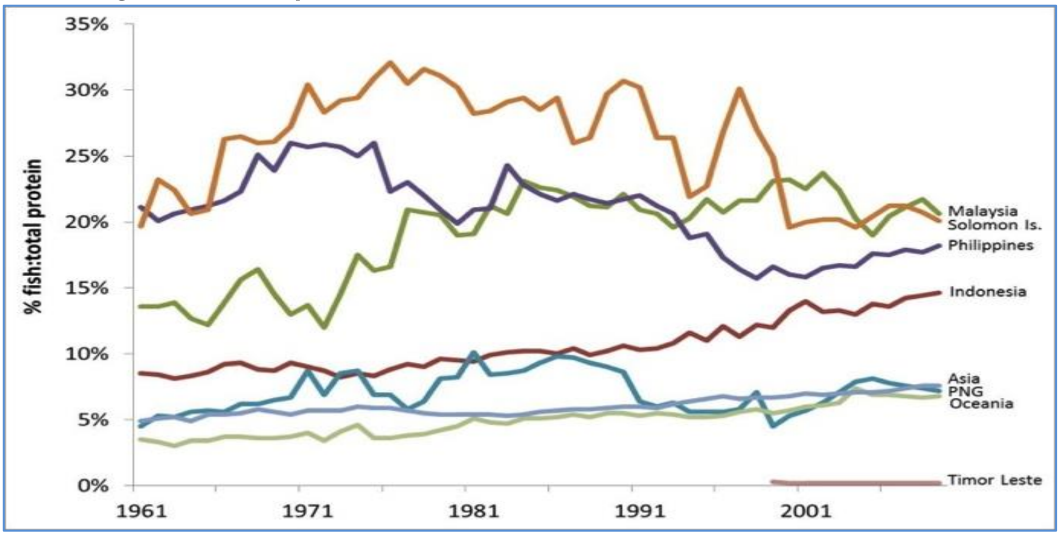
Fish and aquatic invertebrates are important protein sources for most countries in Asia and the Pacific. Per capita fish supply has been increasing since 1961 in Malaysia, the Philippines, and Indonesia and was above the average values for Asia in 2009 (**Fig. 12a**). Malaysia showed the fastest rate of increase, followed by the Philippines and Indonesia. In the Pacific, it is only in the 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 the Solomon Islands reveal a per capita fish supply similar to that in the early 1960s. The values of PNG and Timor-Leste were below the average for Oceania. PNG's per capita fish supply fluctuated between 10–20 kg over the last 48 years.

Figure 12a: Per Capita Fish Supply in the CT6, Asia, and Oceania, 1961–2009



Following the trend in per capita fish supply in Malaysia and Indonesia, the importance of fish as a protein source has also been increasing in both countries (**Fig.12b**). In contrast, the relative contribution of fish to protein consumption has been declining in the Philippines, despite the increasing per capita fish supply. In the Pacific, the pattern for fish contribution to total protein consumption in the Solomon Islands and PNG is similar to the pattern observed for their per capita fish supply, indicative of direct consumption of fish by the population.

Figure 12b: Proportion of Fish to Total Protein Provision in the CT6



Source: FAO, 2010.

D. Status of Fishery Resources

The increasing trends in production for both marine capture fisheries and aquaculture can mislead people to believe that fishing in the CT6 is sustainable and well within carrying capacity limits. The paucity of time-series data on fishing and production costs, as well as the level of effort put into the capture and culture of fish, invertebrates, and aquatic plants obscure the true state of the fisheries in the CT6.

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 the CT6 serve as basis for regulating extraction rates (Lymer *et al*., 2010).

Stock assessments underscore the exploitation status of broad resource categories, e.g., the National Stock Assessment Program [NSAP] in the Philippines. Trophic and size-structure analyses reveal the ecological and biological impacts of intensive fishing (Geronimo and Aliño, 2009; Marine Trophic Index from 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.

A recent FAO report on the status of world marine fishery resources concluded that majority of fish stocks in Indonesia, Philippines, and Malaysia are considered to be at least fully exploited (FAO, 2011). 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**).

Table 12: Fisheries Status in the CT6, 2009

Country	Production (t), 2009 (Source: FAO)[a]	Maximum Sustainable Yield (MSY)	Fisheries Status
Indonesia	4,712,470	5,120,000 t/yr (Lymer *et al*., 2010) 5.0–6.5 million t/yr (Patlis, 2007)	Indonesia's fishery is still expanding but many parts of the resource are overexploited and in decline, particularly the Java Sea and Malacca Straits (Williams, 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	1,616,988 t/yr (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 1970s' level (Williams, 2007; Abu *et al.*, 2003)
Papua New Guinea	217,422 Tuna, bonitos, and billfishes: 213,316 327,471 (including catch and by-catch of foreign-based fleets in 2007) (Gillett, 2009)	0.4 million t/yr for tuna (Mainardi, 2010)	Tuna harvest is above the MSY. It is recognized that there is a regional purse seine tuna vessel overcapacity in PNG (FAO Country Profile: PNG). Current fish consumption in PNG is 13 kg/ person/yr, on the average, which is much lower than the estimated 34-37 kg/person/yer to satisfy the recommended protein intake requirements (Bell *et al*., 2009)
Philippines	2,483,736	2,500,000 t/yr (Lymer *et al*., 2010)	Currently (Years 2010 and 2011) harvesting beyond MSY considering IUU fishing in addition to the unaccounted subsistence fisheries contribution. Fish stocks in major fishing grounds reduced to less than 10% of 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 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 the Solomon Islands due to the rising demand for fish driven by increasing population (FAO Country Profile: Solomon Islands). National average fish consumption is 31 kg/person/yr, which is lower than the estimated 34–37 kg/person/yr to satisfy recommended protein intake requirements (Bell *et al*., 2009).
Timor-Leste	70 $kg/km^2/year$ (Average marine catch/unit area)	140 $kg/km^2/yr$ (average potential marine catch/unit area) (FAO Country Profile:Timor-Leste)	Fisheries are currently underexploited. It will take time to improve fisheries capacity considering the present political and economic condition (Williams, 2007). Timor-Leste achieved independence in 2001.

[a]Classification includes crustaceans, marine fishes, and mollusks, based on ISSCAAP grouping.
Source: Modified from Cabral et al., 2013.

In Indonesia, a substantial decrease in catch per unit effort (CPUE) has been observed from 1990–2007 in bottom trawling, purse seining, and gillnetting. In the Philippines, per capita supply of round scad, dubbed "the poor man's fish", declined from 7.2 g/person/day in 1999 to 4.4 grams/person/ day in 2011 (BAS, 2012).[17]

1. Demersal Fisheries

Demersal finfish fisheries of the CT6 are mostly fully exploited or overexploited. The National Commission on Stock Assessment in Indonesia reports overfishing of demersal fishes in five out of the 11 fisheries management areas (FMAs) and only one FMA was categorized with moderate exploitation (MMAF-JICA, 2011). Scientific surveys conducted in Peninsular Malaysia and Sarawak from 1972–1998 indicate widespread overexploitation and depletion of fishery resources there (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 Pacific countries is unknown, but is presumed to be in poor condition (CEA, 2012).

2. Reef Fisheries

The aggregate reef area of the CT6 is estimated to be approximately 86,000 km^2, excluding reefs in disputed areas, comprising 39,538 km^2 in Indonesia; 22,484 km^2 in the Philippines, excluding reefs under boundary dispute with other countries (Burke *et al*., 2012); 14,535 km^2 in PNG; 2,935 km^2 in Malaysia, excluding reefs under boundary dispute with other countries; 6,743 km^2 in the Solomon Islands; and 146 km^2 in Timor-Leste. 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 at least 120 t/km^2 (McClanahan *et al*., 2011). In the Solomon Islands, 66 reef sites surveyed in 2004 had an average fish biomass of 212 t/km^2 elasmobranchs 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 around 15–30% to the national municipal fisheries production (Aliño *et al*., 2004). Philippine reef fisheries have experienced substantial declines in the past decades, with mean catch rates per vessel declining 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 $t/km^2/yr$ (Maypa *et al*., 2002; Alcala and Russ, 2002; McAllister, 1988). This translates into a sustainable annual yield of 1.29–1.72 million t for the CT6. 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 2.73 million t in 2007 and increased further to 2.93 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 (WCPO), where the Coral Triangle is located, are regularly assessed by the Western and Central Pacific Fisheries Commission (WCPFC). About 59% of world production of tuna comes from the WCPO. 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*) are not yet overfished, on average, for the entire WCPO. However, they are estimated to be at least fully exploited in the CT 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.

[17] Fisheries Supply Utilization Account. http://countrystat.bas.gov.ph. Updated 09-29-2012.

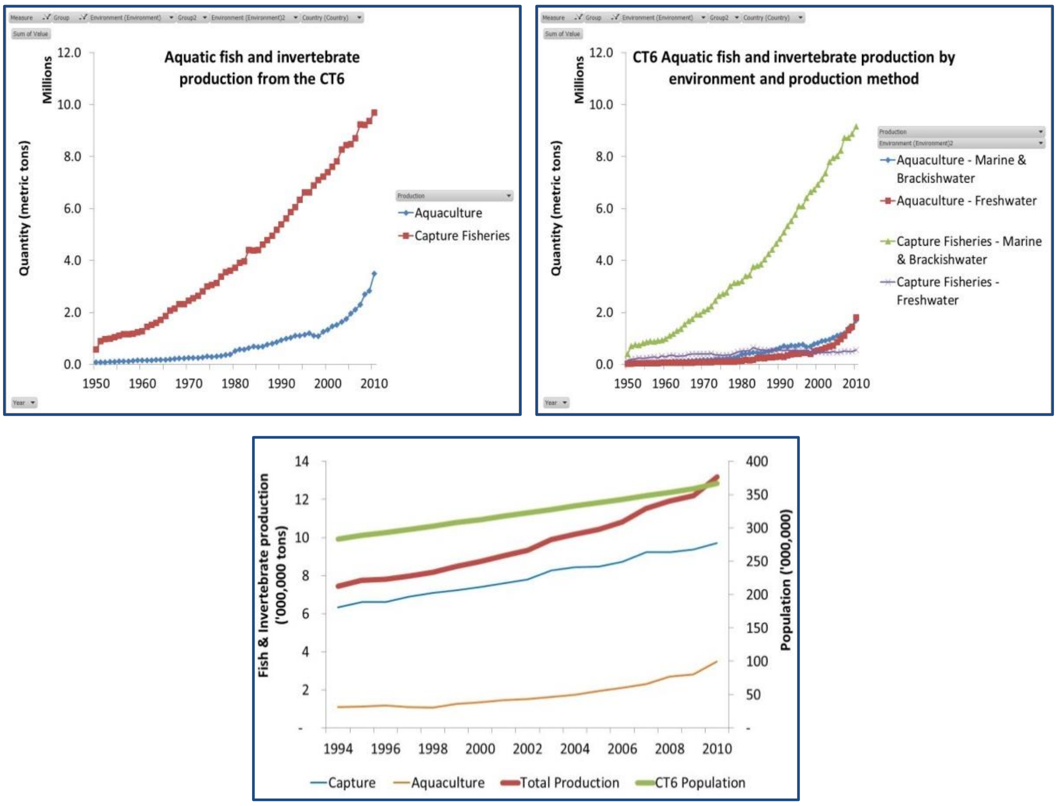
E. Projections of Fish Supply in the CT6

Pertinent drivers of fisheries governance in the CT6 are population and development as well as mariculture/aquaculture. Human population growth rates in the CT6 have been stable over the last five years. The 2010 combined population of the CT6 is around 370 million and, considering a constant rate of population increase, 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 were considered as the bases for projecting production up to the year 2020 (**Fig. 13**). Production was divided into two types (aquaculture and capture fisheries) in two environments (marine/brackishwater and freshwater). Capture fisheries for the CT6, which still remains as the dominant source of food fish for the CT6, have been increasing at an almost linear rate since the 1950s. In contrast, aquaculture production has grown exponentially from 2001–2010, primarily due to the expansion of freshwater aquaculture, although marine and brackishwater aquaculture of fish and invertebrates has shown only a linear trend.

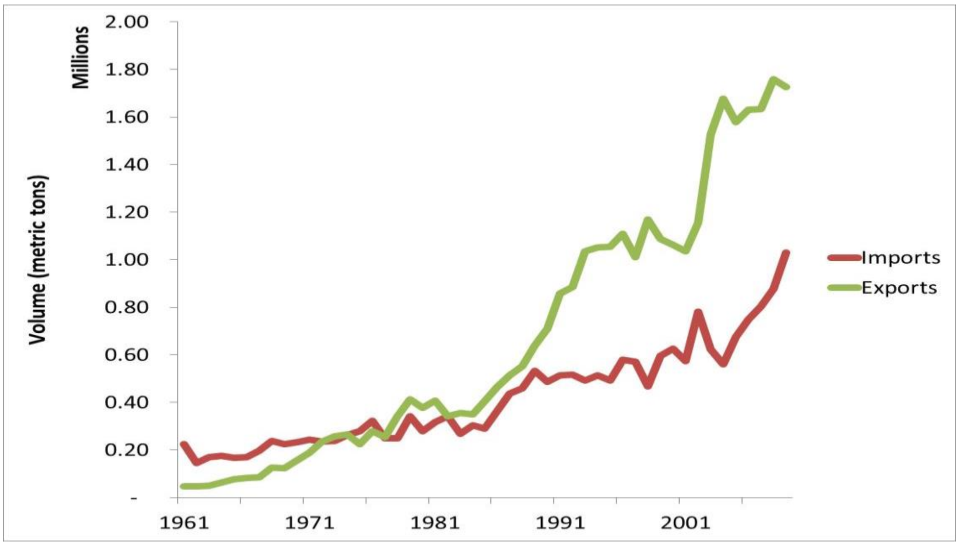
Figure 13: Estimated Growth Trends for Aquatic Fish and Invertebrate Production in the Coral Triangle Countries (upper graphs) and Relative to Population Growth Trends (lower)



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 considers only the trend in the last three years, gave the most optimistic estimate of production in 2020, as compared to projections using average growth rates in the last two 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 help augment food fish supply, while exports reduce available food fish for the countries' citizens. Overall, the CT6 has been a net exporter of fisheries products since 1976 (**Fig. 14**).

Figure 14: Growth Trends in Export and Import of Fisheries Commodities Aggregated for the CT6



Source: Laurenti, 2012.

Projections of fishery commodity imports and exports were made using the linear regression trend from 2005–2009 for the entire CT6 and for the individual countries based on the FAO Food Balance Sheet (Laurenti, 2012). Projections show that by 2020, fish and invertebrate production in the CT6 will increase to a moderate value of 17.1 million t, with a range of 15.5–19.4 million t, compared to 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.[18] Based on the 2010 CT6 per capita fish supply of 33.5 kg, the aggregate per capita fish supply is expected to increase for the CT6 as a whole, even following the slowest projected rate of growth. This projected growth depends more on the expansion of aquaculture production than on that from capture fisheries. Predicted production from capture fisheries does not vary significantly based the different historical trends used in the projections (**Table 13**).

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

Parameter	Aquaculture		Capture Fisheries		Overall	Per Capita Fish Supply (kg/yr)
	Marine and Brackishwater	Freshwater	Marine	Inland		
Base production, 2010 (t)	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 (t)	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 (t)	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 (t)	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 (t)	3,158,903	4,169,959	11,291,416	773,496	19,393,774	45.0

Source: Authors' estimates.

18 Calculated by dividing total fish production of the CT6 by the total population of the CT6.

Population growth rates for most of the CT6 decreased during the period, 1994–2011.[19] However, for Indonesia, whose population accounts for 65% of the total CT6 population, the average growth rate increased from 2009–2011. The aggregate average growth rate of the CT6 over the period, 1995–2011, was 1.64%. Future populations were projected to 2020 using linear regression.

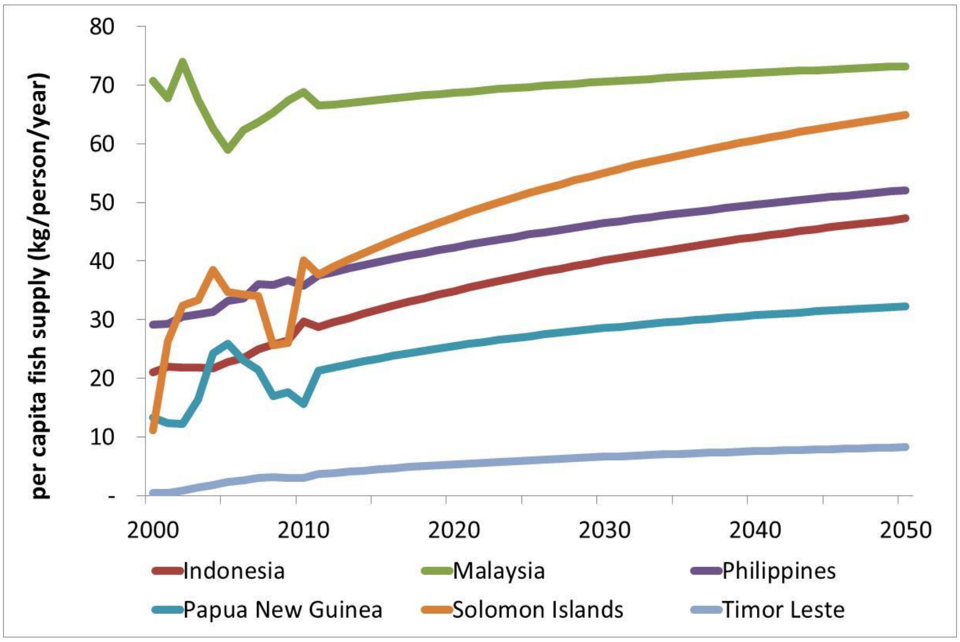
In the worst case scenario characterized by marine capture fisheries no longer expanding, inland capture fisheries catches declining, and aquaculture production developing, following the average trend in the past two decades, the total projected fish production for the CT6 in 2020 is 13.4 million t,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

2. National Projections

Given the importance of fisheries to the economy, poverty alleviation, and food security in the CT6, the countries have set up targets for the further development of their respective fisheries sectors, with most of the countries targeting increased fish production. This section compares the fish production projections based on historical trends to fisheries development targets set by the countries.

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 the CT6 are all likely to increase their per capita fish supply (**Fig. 15**), with Malaysia projected to have the highest per capita fish supply, followed by the Solomon Islands, the Philippines, Indonesia, PNG, and Timor Leste. The high per capita fish supply of Malaysia assumes 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 three-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 three years (**Table 14**). Thus, these countries will have to improve their fisheries production performance from that in the period, 2008 –2010, for them to be able to meet fisheries demand and at least prevent per capita supply from dropping.

Figure 15: Projected Per Capita Fish Supply in the CT6, 2000–2050



Source: Author's estimates based on the rate of growth of production, population, and trade from 2001–2010.

[19] http://www.adb.org/statistics/

Table 14: Predicted Per Capita Supply of Fish and Invertebrates in the CT6 in 2020 at Different Production Growth Rates

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

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

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 (GVA) 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 and municipal fisheries production targets for 2016 have been set at 16% and 19% of 2010 values or 1,447,000 t and 1,636,000 t, respectively. 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 Philippine Government for 2016 can realistically be achieved. Using the historical trend from 2001–2010, predicted capture fisheries production for the Philippines 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 trend.

However, over the three years, 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% from 2001–2007. If this three-year trend persists, per capita supply of fish is projected to decline from the 2010 estimate of 37.21 kg/person/yr to 30.61 kg/person/yr by 2030. Production will also fall short of the Government's 2016 targets for capture fisheries and aquaculture by 309,000 t and 580,040 t, respectively. Other indicators of fisheries development identified in the 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.

Indonesia. News articles reveal 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 the McKinsey Global Institute's (MGI) report (Oberman *et al*., 2012).[20] The MGI report predicts that a 7% per annum growth in real revenue from agriculture 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

[20] Listiyarini, T. 2012. *Indonesia's Fishing Sector Targets $240 Billion by 2030*. Jakarta Globe, 29 December. (http://www.thejakartaglobe.com/business/indonesias-fishing-sector-targets-240-billion-by-2030/563899)

$210 billion 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, MMAF initially set a high target of 22.39 million t of fish by 2015, almost double the reported fisheries production of 11.7 million t in 2010,[21] but the target was set for review and re-targeting a month later.[22] Aquaculture production is targeted at to grow at 27% per year from 2010–2014.[23] Indonesia also targets to increase its fisheries product export value by at least US$500 million in 2013 from $4 billion in 2012,[24] and plans to expand its export base for fishery products to the Middle East and Africa in addition to its existing three big markets—United States, Japan, and the European Union.[25]

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 rate. 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.

Papua New Guinea. Using a comprehensive model of supply and demand for fish products, Bell et al. (2009) predicted that PNG and the Solomon Islands will have problems meeting their future demand for fish. This is also reflected in the forecasts using the trend observed from 2008 –2010. The PNG Strategic Development Plan for 2010–2030 (DNPM, 2010) targets 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/yr in 2007 (Laurenti, 2012). Nearshore subsistence fishing currently meets 60% of the consumption needs of the Solomon Islands, with fish accounting for almost 94% of animal protein consumed (Weeratunge *et al*., 2011). Projections based on FAO data for fisheries production shows a highly optimistic future for fish supply in the Solomon Islands. However, Bell et al. (2009) and Weeratunge *et al*. (2011) predict 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 the Solomon Islands will depend on (i) improving the country's processing facilities to extend the life of fishery products and allow their distribution to fish-scarce areas, (ii) stimulating domestic fisheries to access abundant resources currently 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 in Timor-Leste, since relatively few Timorese are actively engaged in fishing. Projections on aquaculture production to 2030, using linear forecasting based on aquaculture production estimates from 2004–2010, yielded a production of 7,806 t by 2030, as compared to the 12,000 t targeted by the Government in 2030 (NDFA/MAF, 2012). Per capita fish consumption rate in Timor-Leste was estimated at 6.1 kg/yr (NDFA/MAF,

[21] Jakarta Post. 2011. *Govt aims to produce 22.39 million tons of fish by 2015*. 7 October. (http://www.thejakartapost.com/news/2011/10/07/govt-aims-produce-2239-million-tons-fish-2015.html)

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[25] Baskoro, FM. 2012. *Indonesia to Expand Fishery Exports to Middle East, Africa*. Jakarta Globe. 26 December. (http://www.thejakartaglobe.com/business/indonesia-to-expand-fishery-exports-to-middle-east-africa/563582)

2012). This is higher than that calculated using data from FAO, which estimated a per capita consumption rate of only 3.0 kg/yr in 2010.

F. Summary and Conclusions

Fishing and fish farming are important contributors to the national economies and trade in the CT6. 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 the CT6 was estimated at $11.7 billion, directly employing at least 4.6 million people in the CT6 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 the CT6 continues to rise in most countries. Aquaculture, both marine/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 the CT6, with inland aquaculture augmenting the supply to a limited extent. Marine and brackishwater aquaculture make very minimal contributions to fish supply since seaweeds comprise the bulk of the produce.

Projections of fish and invertebrate production highlight continued growth in fish supply in the CT6, 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 produce in the CT6 by 2017. However, given the rate of freshwater aquaculture expansion observed in Indonesia, a big part of fish supply for the CT6 (as a region) in the future is likely to 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 to volume sufficiency, for the CT6 as a region unless growth trends are reversed.

Aquaculture currently plays an important role in assuring fish supply in the CT6, 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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CHAPTER III

AQUACULTURE DEVELOPMENT TRENDS AND IMPLICATIONS IN THE CORAL TRIANGLE

A. Introduction

Traditionally, aquaculture has been treated askance by conservation projects similar to the CTI, mainly because of its likely adverse impacts on the environment. SEAFDEC-AQD (2012) summarizes the negative externalities associated with the phenomenal growth of aquaculture as follows: modification, destruction, or complete loss of habitat; unregulated collection of wild broodstock and seeds; translocation or introduction of exotic species; loss of biodiversity; introduction of antibiotics and chemicals into the environment; discharge of aquaculture wastewater, thus coastal pollution; salinization of soil and water; and dependence on fishmeal and fish oil as aquaculture feed ingredients, to name a few. These are some compelling reasons why aquaculture should be mainstreamed into the CTI framework as it poses a threat or hindrance to the implementation of the EAFM and marine protected area (MPA) management and aggravates climate change impacts. Moreover, there are interactions between capture fisheries and aquaculture, which need to be analyzed from an economics perspective, in order to guide the actions of private decision makers and inform the formulation of appropriate policies on resource use and management, among others (Willmann, 2007).

Hence, this chapter revisits the CTI RPOA and the NPOAs of the six countries to see how aquaculture is integrated with the broader fisheries management framework and whether or not countries view aquaculture as distinctly separate from fisheries management (Section B). It also discusses trends in aquaculture, past and future, with emphasis on government strategies (Section C), and estimates future demand for trash fish, based on historical information, and computes the financial requirements (Section D). 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, in the hope that the information will guide the other CTI countries in their pursuit of aquaculture development (Section E).

B. Aquaculture in the CTI Plans of Action

The RPOA is largely silent on aquaculture (apart from elaborating the individual NPOAs in the Annex). This reflects a 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 the EAFM goal, 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 the live reef fish trade requires a full-cycle culture technology to stop exploitation of juvenile fish. Two countries made explicit mention of activities related to aquaculture in the RPOA. In the Timor-Leste NPOA, Action 3 under Goal 2 mentions the development of marine and brackishwater culture (e.g., seaweed, sea cucumber, milkfish, and groupers), while the Philippines NPOA mentions full-cycle culture for live reef fish species.

The treatment of aquaculture in the NPOAs is sparse and, though most countries recognize the potential for aquaculture as a strategy for food security and poverty reduction, it remains separate from the EAFM framework espoused in the CTI. It must also be emphasized that of the six countries, four—the CT-SEA plus PNG—fully utilized the RPOA structure (Goals/ Targets/Actions) as templates for their national plans, while the Solomon Islands and Timor-Leste developed their NPOAs based on their desired priorities. Some degree of overlap can be observed for Timor-Leste (EAFM, Priority Marine Conservation Areas, and Climate Change) while the Solomon Islands capitalizes on community-based resource management (CBRM) through cross-cutting themes, including CBRM implementation, policy and legislation, 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 Target 2 on Coastfish and the 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 (DGA), which is also under MMAF), but is largely uninvolved with CTI concerns.

Table 15: Aquaculture, as Elaborated in the CTI NPOAs, and Related Policies

	NPOA Recognition of Aquaculture under Goal 2: EAFM	**National Plans and Strategies Related to Aquaculture**
Indonesia	• Target 2, Action 2: Develop community based capture fisheries and aquaculture enterprise in the border and remote areas. • Target 2, Action 3: Develop certification schemes for aquaculture products. • Target 2, Action 3: Conduct monitoring and evaluation for aquaculture. • Target 2, Action 4: Develop fisheries product standard. • Target 4, Action 2: Develop best practices for live reef fish trade, wild capture or aquaculture.	*MMAF Strategy*
Malaysia	• Target 2, Action 1: Nominate selected coastal communities in Sabah to participate in the Coastfish program. • Target 2, Action 2: As a Sulu Sulawesi Marine Eco-region (SSME) 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. • Target 2, Action 3: Rehabilitate abandoned shrimp farms to their natural state or for other sustainable aquaculture uses. • Target 2, Action 4: Address problems faced by seaweed farmers. • Target 2, Action 5: Develop economically feasible and ecologically suitable seaweed farming using best culturing techniques and seaweed strains in Sabah. • Target 4, Action 2: Implement and adopt full-cycle aquaculture to alleviate pressure on wild stocks. • Target 4, Action 2: Implement best management practice for aquaculture, with emphasis on the production of reef fish.	*Third National Agricultural Policy* *National Agri-Food Policy (2011–2020)*
Papua New Guinea	• Target 2, Action 6: Build marine aquaculture research station in Kavieng.	Corporate Plans of the National Fisheries Authority pursuant to the *Fisheries Management Act of 1998*
Philippines	• Target 2, Action 3: Conduct sustainability assessment of aquaculture production to attain twin objectives of food security and provision of livelihood opportunities. • Target 4, 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.	*Comprehensive National Fisheries Industry Development Plan* *Medium Term Development Plan*
Solomon Islands	Based on Key MECM/MFMR Policy Overlaps: • Livelihood supplementation options: Test in 3 provinces, fish aggregation devices, freshwater culture, seaweed (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*

	NPOA Recognition of Aquaculture under Goal 2: EAFM	National Plans and Strategies Related to Aquaculture
Timor – Leste	Goal 1, Target 4: • By third quarter of 2010, Timor-Leste will have started engaging with potential partners to define strategies to diversify the 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 Development Strategy, 2012–2030

EAFM = ecosystem approach to fisheries management, MECM = Ministry of Environment, Climate Change, Disaster Management and Meteorology, MFMR = Ministry of Fisheries and Marine Resources, NPOA = National Plan of Action, SMIFMR = Strategy for the Management of Inshore Fisheries and Marine Resources.

Malaysia has effectively woven aquaculture into Goal 2 by focusing on livelihoods, environment, technology, and knowledge transfer. It uses the Sulu Sulawesi Marine Eco-region (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 a *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/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).

PNG's NPOA recognizes the linkage between coastal fisheries and aquaculture as what is intended by EAFM, yet none of its activities under Goal 2 reflect this thrust except for mention of research in marine aquaculture by Kavieng College. PNG's aquaculture strategy is developed mainly by the National Fisheries Authority (NFA) 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). A *National Aquaculture Plan (2009–2014)* has been prepared and priority commodities identified based on two prioritization exercises. The prioritized commodities are seaweeds, sea cucumber, tilapia, and marine ornamentals.

Timor-Leste's elaboration of aquaculture in its NPOA recognizes aquaculture's role in income generation and poverty alleviation. It includes, as a CTI activity, the preparation of an aquaculture strategy, already duly accomplished, in which aquaculture is promoted as a means to combat prevalent malnutrition.

C. Aquaculture Development in the Coral Triangle

As discussed in Chapter II, total fishery production of the CT6 reached 19.1 million 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 the three Southeast Asian countries of the CT6, aquaculture has had a long history and is presently contributing significantly to domestic food requirements, export revenues, and employment. In contrast, the Pacific countries of PNG and the Solomon Islands have experienced a floundering aquaculture sector, but there is a resurgence of interest mainly due to increasing populations and food requirements. Timor-Leste's approach is articulated in the *Aquaculture Development Plan*, which aims to combat widespread malnutrition by raising annual per capita consumption levels from 6.1 kg to 15 kg, in order 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 markets, aquaria, and pharmaceutical inputs; and pristine coral reef ecosystems utilizable for restocking and stock enhancement. However, the challenges are many and include high transportation costs and lack of domestic markets, freshwater resources, physical infrastructure support, and technology and knowhow.

Indonesia. This country has vast resources which offer a huge potential for aquaculture development. At the national level, the extent of areas with potential for aquaculture is estimated at 15.59 million hectares (ha), composed of 2.23 million ha of freshwater bodies, 1.22 million ha of brackishwater areas, and 12.14 million ha of marine areas. To date, only 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) due to 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; shrimps now 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) reports that aquaculture in marine areas is now growing faster than in brackish waters, owing to the huge demand for seaweeds and the Asian seabass.

Malaysia. This country has had a long history of aquaculture, starting in the 1920s with 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 became 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 recorded the highest production, followed by marine shrimp and freshwater species, such as tilapia, carps, and catfish, as well as marine fish. Cockles account for almost 50% of the total brackishwater aquaculture production and about 37% of annual aquaculture production.

Much of the freshwater commodities is marketed domestically while tiger prawns (shrimp), groupers, and seabass are exported to Singapore; Taiwan, China; and Hong Kong, China. NAP3 targeted a 200% production increase in aquaculture by 2010, but failed to achieve this due to difficulties in land acquisition, rising production costs, and lack of skilled workers. As a manifestation of its serious commitment, the government declared an 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/aware, requiring high product standards and environmental safeguards.[26]

Philippines. From 2001–2011, the aquaculture sector in the Philippines produced an average of 2 million t worth P60 billion ($1.5 billion) annually. Food fish (excluding seaweeds) comprised 31% of the total volume produced and 89% of the value. Aquaculture contributes significantly to the

[26] http://thestar.com.my

country's food security, employment, and foreign exchange earnings. Approximately 18% of fish food supply comes from aquaculture, notably milkfish and tilapia (FAO, 2008). 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).

Lopez (2006) enumerates some of the issues the country has to address to improve sector performance. These include stringent hazard analysis and critical control point (HACCP) protocols that fish farmers find hard to comply with due to 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 role in providing food, incomes, 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’ in the hope of attracting private sector investment and improving accessibility of produce to consumers. At present, 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 groupers, rabbitfish, and jacks.

PNG. The PNG State of the Coral Triangle Report (SCTR) acknowledges that aquaculture in the country is not well-developed (PNG CTI NCC, in press), 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 non-existent. 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 to be unsuccessful, except for tilapia, which escaped into the Sepik River and now account for roughly half of the yield of the capture fishery there.

PNG aquaculture development was stagnant until recently, with low-level commercial operations for trout, barramundi, pearl, and shrimp.[27] The Australian Centre for International Agricultural Research (ACIAR) reported that in 2007, there were 5,418 known tilapia farms operating 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 great. Edwards (2009) recommends the Markham Valley as having potential for large-scale commercial aquaculture because it has a flat topography, has more available water, has land that is more readily accessible, and is close to the major urban market of Lae, with 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 (NARI) to use local materials as feed sources for pond fish, and supporting 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 the Solomon Islands, despite the wide range of species cultured, viz., giant clams, shrimps, freshwater prawns, pearl oysters, seaweed, sea cucumbers, hard and soft corals, milkfish, sponges, and the capture/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 the Solomon Islands offers opportunities to create new livelihoods and export commodities, while freshwater aquaculture can supply fish for food in areas

[27] www.fisheries.gov.pg

where inshore fisheries are limited and tuna are difficult to access (SFIMFMR, 2009). Thus, 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) development of 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).[28]

Timor-Leste. Similar to the Solomon Islands, the period of conflict with Indonesia wiped out all aquaculture activities in 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 seaweeds comprise the main marine aquaculture crop in Timor-Leste. One 3-ha farm visited outside Dili produced around 2 t/yr in 2008 and 2009, equivalent to $1,300/yr. Seaweed is exported, with reported markets in Indonesia, the Philippines, and Vietnam, and there is some very limited local consumption of some species (Andrew *et al*., 2011). Freshwater aquaculture, particularly of common carp, was promoted in Ermera, Aileu, Manufahi, and Viqueque districts, where freshwater fish hatcheries were established.

Timor-Leste prepared an *Aquaculture Development Plan* as an activity under Goal 2 of the NPOA because the country's *Strategic Development Plan through 2030* gives due 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 kg in the medium term and contribute to up to 40% of domestic fish supplies in the long term (Ministry of Agriculture and Fisheries, 2012). Priority districts and aquaculture types are as follows:

1. *Freshwater aquaculture:* Bobonaro, Ermera, Baucau, and suitable agro-ecological 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.
2. *Brackishwater aquaculture*: Existing brackishwater aquaculture sites in Dili, Liquica, Manatuto, Covalima, and Oecussi districts. Milkfish, seaweeds, and possibly shrimp are the target species.
3. *Mariculture:* Dili, Liquica, and Manatuto districts. Sea cucumber and possibly mudcrabs are the target species.

D. Interactions between Capture Fisheries and Aquaculture

The interactions between capture fisheries and aquaculture are varied. While this section focuses on aquaculture's demand for trash fish for reduction purposes, other issues that highlight the need for more integrated management of aquaculture and capture fisheries abound, including alien species introduction mainly for aquaculture purposes but with risks of escape (Coates, 1989), disease, damage to habitats and wild biodiversity, pollution, biotechnology concerns (transgenic fish), and capture-based aquaculture (collection of juvenile for growout such as 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 development activities, and share the same resources (human and capital). Unfortunately, the approach to policy development and institutional arrangements does not reflect this, and neither is it apparent in the CTI.

While recognizing the many issues characterizing capture fisheries/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 poverty alleviation, also poses a threat due to the increasing demand for trash fish, which are consumed as food fish in less developed economies. In addressing the overall food security outcome of CTI, the EAFM strategy must consider synergies and tradeoffs 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 three Southeast Asian countries on marine aquaculture and the preference for high-value species.

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

Ye and Beddington (1996) suggested that aquaculture is 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. In order to sustain the demand for food fish spurred by growing populations and improved incomes in both the CT6 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. There is also concern that long-term sustainability of both aquaculture and capture fisheries is threatened. Carnivorous fish such as groupers, snappers, and barramundi directly consume trash fish, while they are converted into components of fishmeal for milkfish and shrimps. Trash fish remains the method of choice for many farmers, especially for those who presently farm low-volume species, such as snapper (*Lutjanidae* spp), grouper (*Epinephelus* spp. and other serranids), and many other marine fish where aquafeed manufacturers find it difficult to develop economically competitive pelleted feeds as an alternative to trash fish (Williams and Rimmer, 2007). Stobutzki *et al.* (2007) estimated that in 2003, the requirement for trash fish to be used directly as aquaculture feed was 16,000 t in the Philippines, 96,000 t in Indonesia, and 45,000 t in Malaysia; the requirement for trash fish as pellet components is close to 500,000 t. The individual CT countries' likely demand for trash fish to sustain their aquaculture targets is assessed below based mainly on each country's agricultural or aquaculture strategy and news reports.

Malaysia's NAP3, which ended in 2010, showed a shifting focus to marine finfish from shrimp farming, which had traditionally dominated aquaculture production, due to higher income and export potential. Initially regarded as a small/backyard industry, marine finfish farming is now a commercial enterprise that produces high-value marine species, such as groupers, seabass, 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 five years' time, higher than current production of 380,000 t, in cognizance of the higher demand brought about by the increasing population.[29] Using the same proportion of marine fish from NAP3 (i.e., 20% of total targeted production), it is estimated that 160,000 t of fish is targeted for aquaculture production, which translates into a requirement of 800,000 t of trash fish, based on a 5:1 food conversion ratio (FCR) (FAO, 1985).

Aquaculture production in **Indonesia** reached 6.98 million t in 2011, and the target for 2012 was 9.4 million t.[30] 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, and the catch of Bali sardinella *(lemuru)* of 162,000 t is considered as an indication of the trash fish requirements of Indonesian aquaculture.

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).

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

The national aquaculture strategy of **Timor–Leste** aims to increase fish supply from aquaculture to a target level 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, it is envisioned that at least 40,000 households will derive income benefits from this form of aquaculture. For marine aquaculture, the target species are sea cucumber, seaweed, and crabs. Thus, the demand for trash fish for aquaculture is low in Timor-Leste. The same is true for the Solomon Islands, based on the *National Aquaculture Strategy (2009–2014)* and the priority commodities indicated in **Table 16**.

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29 *New Straits Times*, 13 July 2012.
30 International Conference for Aquaculture in Indonesia.

Table 16: Value of Trash Fish Required for Aquaculture in the CT6

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
Malaysia	High, about 800,000 t based on a target production of 165,000 t of marine fish and average FCR 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.) Jew fish (*Pseudosciaena* spp.) Lizard fish (*Saurida* spp.) Squids Mantis shrimp	$640 million based on a price of $0.80/kg
Timor-Leste	Low	None, focus is on freshwater culture of carp and tilapia	Not applicable	Not applicable
Philippines	Medium, about 128,000 t based on historical usage	Grouper Cavalla Snapper	Roundscads Fusiliers	$90 million based on a price of $0.70/kg
Indonesia	Medium, historical demand is 150,000 t of fishmeal a year	Grouper Gourami	Pelagic fishes like the Bali *sardinella (lemuru*) are the best base for fishmeal due to their high protein content. Other species also 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
Solomon Islands	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
Papua New Guinea	Not estimated	Historically, rainbow trout and tilapia in highland farms; mariculture emphasis on seaweed, giant clams, crocodile, milkfish, mullet, mussels, oysters, and prawns		Not estimated

[1] Production targets are based on pronouncements of Fisheries Department (New Straits Times, 13 July 2012) and percentage composition of major species group is based on *Third National Agricultural Policy* (Othman, undated). 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 per kg during high season (Stobutzki *et al.*) and RM5 per kg during low season (Chun, 2007) or average of US$0.80/kg based on exchange rate of RM3 = US$1.

[2] Based on Timor Leste *National Aquaculture Strategy.*

[3] Target for 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 price of roundscads and fusiliers of USD 0.73 to USD 1.7/kg (Bureau of Agricultural Statistics)

[4] Indonesia information is based on the position paper entitled, "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); price is based on IDR4,000/kg of US$0.50/kg based on US$1=IDR9600 based on presentation of Gede Sumiarsa and Lukas Manomaitis on *Fish Aquaculture Production with regard to Feed and Feeding Management* In Bali, Indonesia.

[5] Based on National Aquaculture Plan

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

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 the CT6, based on current plans and targets. Incorporating trash fish for reduction purposes (fish meal, pellets, and fish oil) shows that the estimates are conservative. This is 20% of total aquaculture production for the Southeast Asian countries. The estimate is not surprising given that in 2006, the global consumption of the aquaculture sector was the equivalent of 23.8 million t of small pelagic forage fish in the form of feed inputs, including 3.7 million t of fishmeal and 0.83 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/trash fish as a direct feed or within farm-made aquafeeds (Tacon and Metian, 2009).

In less developed economies, the term "trash fish" is fish with low commercial value. It does not mean that it is unpalatable and useless, especially if further processing can transform 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 feed the wealthier sector. Due to the increasing demand for trash fish as feeds for carnivorous species, prices have increased, which, in turn, resulted in 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 complying strictly 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, and most of the dominant families comprising trash fish are being exploited beyond MSY, especially fish that have other commercial value (Stobutzki *et al.*, 2007). The same report counts 12 out of the 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.

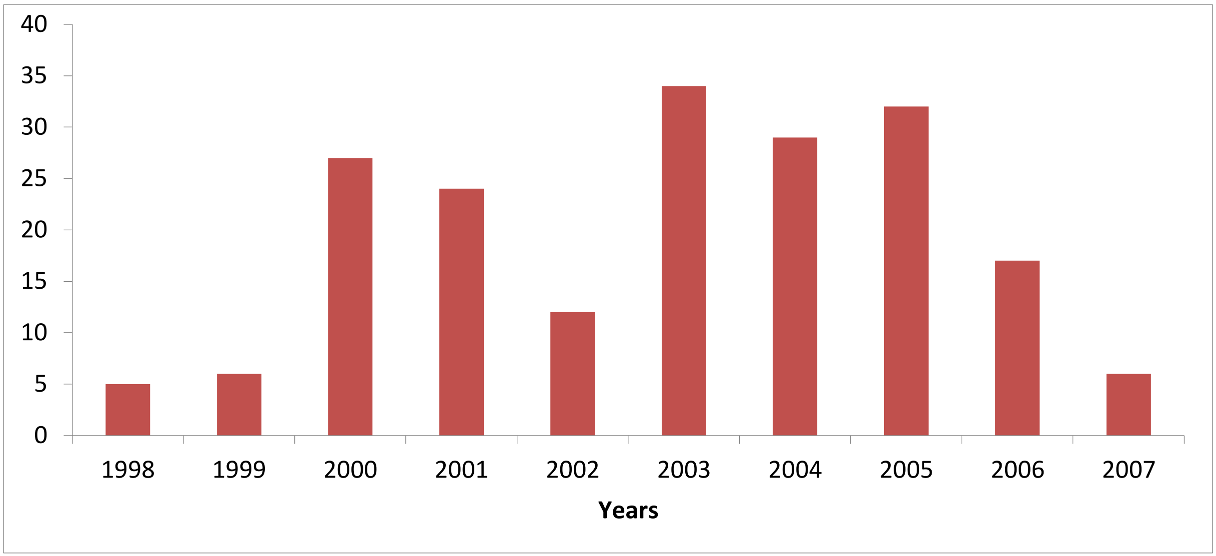
The resources required to support marine aquaculture, not to mention the indirect use of trash fish as components of fishmeal, are enormous. While aquaculture contributes to food and incomes, its development thrust must not be pursued in a vacuum, especially when such relationships with capture fisheries 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 illustrate 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. The 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 due to infectious or non-infectious causes in wild or captive fish or shellfish populations. Oxygen depletion, pollutant toxins, natural toxins, and disease 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 BFAR Fish Health Monitoring Service, 192 fish kills occurred from 1998–2007 (**Fig. 16**). 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. 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 fry/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 the 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 Taal Lake, affecting freshwater cages and pens farming tilapia, as well as in the coastal municipalities of Anda and Bolinao in the province of Pangasinan, where cages of milkfish were affected.

Figure 16: Fish Kill Occurrences in the Philippines, 1998–2007



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

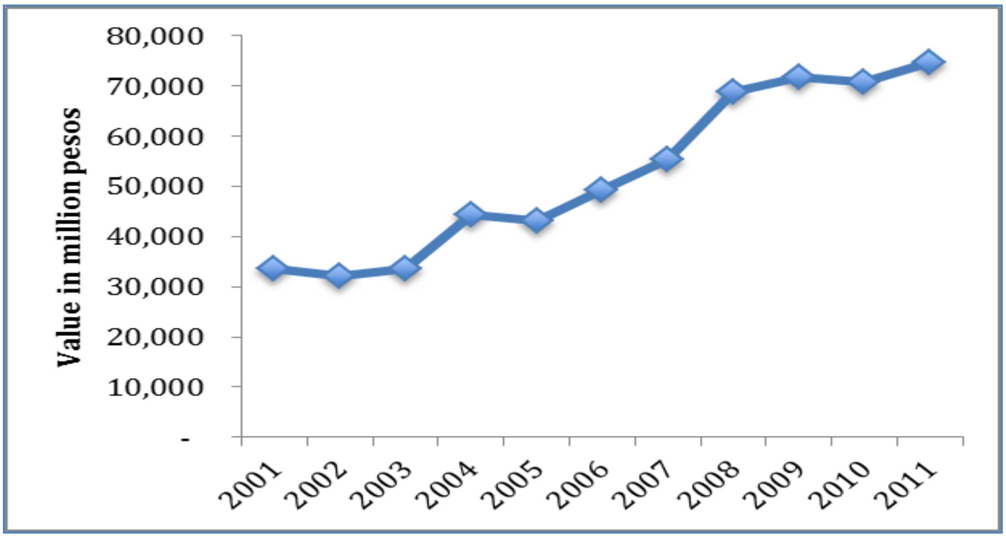
The largest and most publicized fish kills can be traced to irresponsible aquaculture. In Bolinao, Pangasinan, two major fish kills occurred in 2002 and 2007, and a minor one in 2011. All incidents can be traced to overstocking, overfeeding, and overcapacity of cages in the Caquiputan Channel, where water flushing was observed to be slow. In 2002, the losses were estimated at P200–P500 million, while in 2007,[31] the losses were placed at P70–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, a freshwater lake located south of Manila, 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, news about 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 (DA), the National Disaster and Risk Reduction Management Council (NDRRMC), 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.

[31] The exchange rate of the Philippine Peso (PhP) to the US$ in 2002 was PhP51.6 to $1; in 2007, it was PhP46.15 to $1; in 2011, the rate was PhP43.31 to $1.

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 are P30–70 billion, thus rendering even the maximum loss of P500 million relatively insignificant (**Fig. 17**).

Figure 17: Value of Philippine Aquaculture Production (excluding Seaweeds)



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

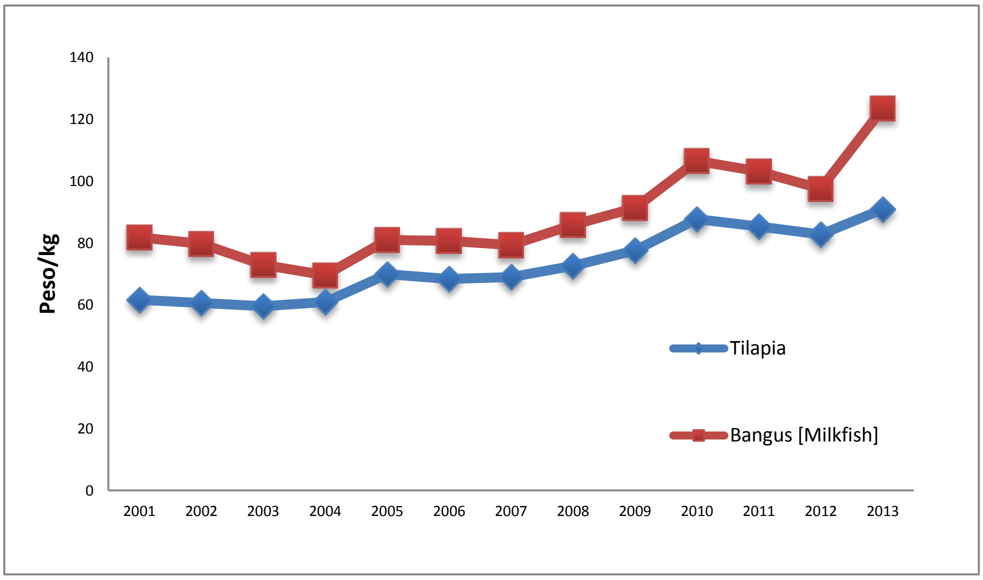
However, the 2011 fish kill in Lake Taal provides a good example of various "hidden" costs. Aside from the direct costs associated with the dead fish, the other economic costs are: (i) cash released by DSWD for work costs amounting to almost P9 million; (ii) other costs of national and local agencies 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 Taal Lake incident represents a little less than 10% of the annual production of tilapia. However, this same quantity of fish can feed almost 60,000 people for one year based on a per capita consumption of 38 kg/yr. A survey of tilapia farming conducted by ADB shows that fish is consumed 5-6 times a week in households along lakeshore municipalities and that 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 directly affect the supply of milkfish in Metro Manila markets because this region provided 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% during 2001–2013 (**Fig. 18**). By increasing stocking density, production per unit volume of water increases, thus increasing total profits. Already, return on investment (ROI) for a typical bamboo cage (5x10x2.5m) and 2,000 fingerlings for stocking is 54%.[32] Increasing stocking density by 500 fingerlings results in an ROI 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.

[32] www.region2.bfar.da.gov.ph

Figure 18: Retail Prices of Tilapia and Milkfish in the National Capital Region, Philippines, 2001–2013



Source: BAS, *Fisheries Statistics of the Philippines,* various issues

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., in this case, 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, in the opportunity costs of dead fish feeding thousands of people and of borrowed operating capital that 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 which 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 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 Southeast Asia is expected to continue expanding, with Indonesia still operating at below capacity levels and the Philippines struggling to meet export standards and implement 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 Pacific countries will experience high population growth, urbanization, and a continuing shift from subsistence to cash economies. With inshore resources being depleted, the countries are now taking a serious but cautious stance towards 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 non-food fish will come from one of three sources (fish farms/aquaculture, aquaculture-enhanced fisheries, and fisheries that adopt efficient management systems) (FAO, 2012), thus highlighting the need for a more integrated approach towards capture fisheries and aquaculture.

This study, therefore, offers the following recommendations:

- As food security is one of the higher-level outcomes of the CTI, and aquaculture is used by countries as a strategy towards 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) recommend 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.

- The role of aquaculture within the EAFM framework needs to be articulated in order 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 need not map out specific activities within the purview of aquaculture; instead, focus must be placed on policy harmonization and linkages.

- 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 both at the local/site level and national level so that the impacts of fish kills and other environmental disasters associated with aquaculture are not trivialized. Cost and benefits associated with the utilization of trash fish as aquaculture inputs should also be analyzed with a 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 did rough estimates on catches of *ikan kembong* (*Rastrelliger kanagurta*) 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.[33]

- The CTI must be utilized as a forum for knowledge sharing on best aquaculture practices as well as 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), SEAFDEC, and SSME, for knowledge sharing.

- 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 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/ disbursement of earnings.

[33] "*Ban trawl fishing now to prevent the collapse of our fisheries*". www.consumer.org.my

- 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 in order to increase its economic value. Technological innovation is another option. For example, the Philippine government supported the development of an underwater robot dubbed “Roboteknik” to serve as an early warning detection for fish kills, especially in freshwater lakes.

- 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 in economic power can have greater access to such information, which gives 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 should promote a level playing field and provide greater access to the requisite information (e.g., through education, information campaigns, and consultation) and secure greater transparency in governance. Transparency implies participation of all stakeholders in planning land and marine use.

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CHAPTER IV
CONNECTIVITIES IN THE CORAL TRIANGLE

The 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 six individual CT countries. This chapter characterizes three layers of connectivities – 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 co-existence of thousands of species in patches and long stretches of coral reefs (Hoegh-Guldberg *et al*., 2009).

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

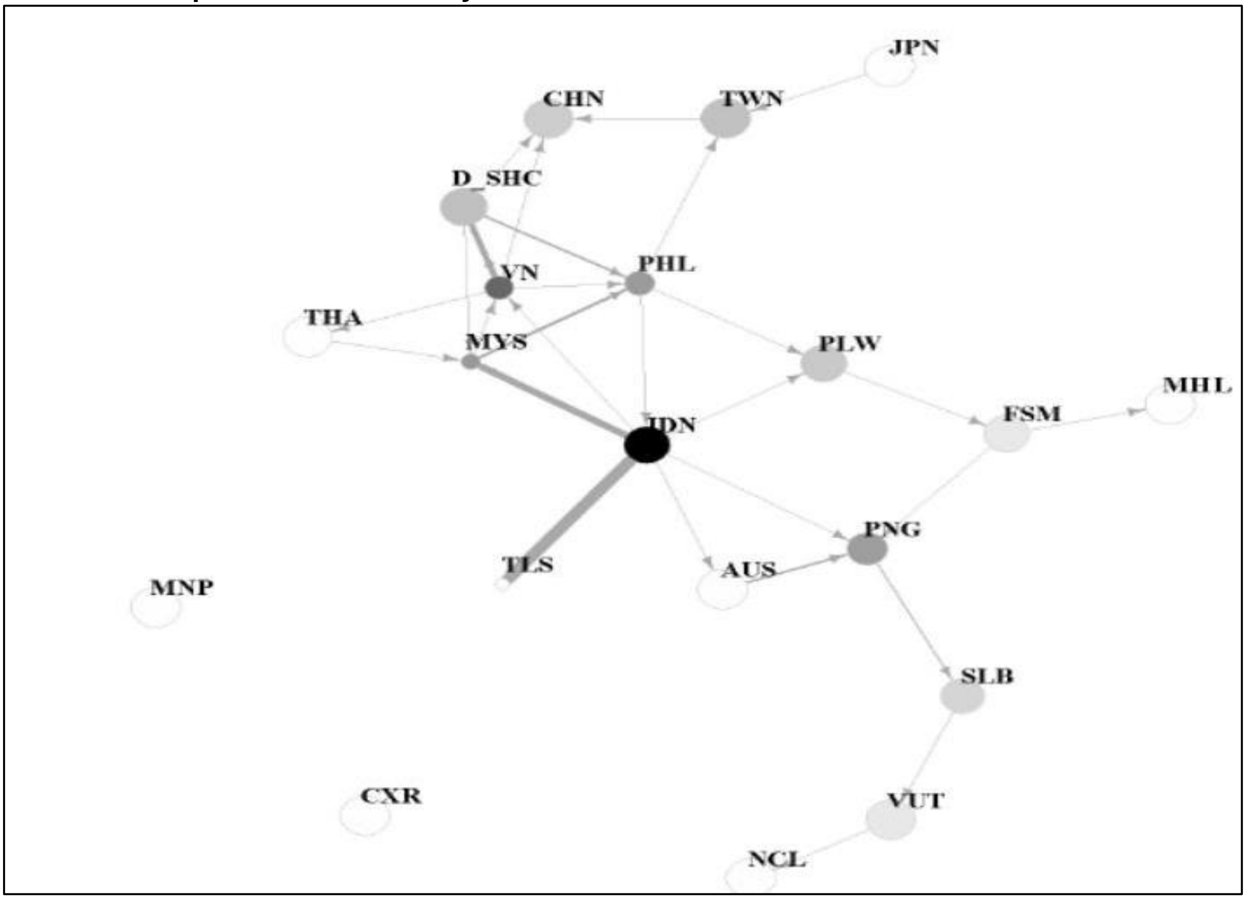
Biophysical connectivity in the marine environment can refer to the following: (i) migration of animals between habitat patches; (ii) dispersal of larvae from spawning locations to downstream habitats; and (iii) flow of nutrients, sediments, and toxins from a watershed to an estuary. In areas with strong 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 (IWP). 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 throughout the IWP. Two-thirds of larvae that are able to settle on reefs do so within less than 120 km from their source reefs. However, there are notable connectivities across the IWP. Projecting the connectivity matrices over time resulted in three distinct blocks representing clusters of larval exchange in the IWP: (i) in the South China Sea between the Spratly Islands and the Philippines; (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 Banda Sea; and (iii) between the reefs of PNG and the Solomon Islands.

Complementing and corroborating the work of Kool and colleagues (2011), Treml and Halpin (2012) developed separately a larval dispersal model for the CT region extending up to the South China Sea, Japan, Australia, and other Pacific islands and territories north and south of the CT boundary. Factoring all rare or weak dispersal connections, they predict that all the CT 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 CT. 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 Philippines; Central Indonesia from Makassar Strait to the Flores Sea; Halmahera Sea; and the southeastern islands of PNG (Treml and Halpin, 2012).

Treml and Halpin (2012) analyzed the larval dispersal connectivity patterns in terms of networks across countries, ecoregions, and seascapes in and around the CT. This approach allowed them to relate larval dispersal patterns and strengths of connectivity to conservation planning units. The larval dispersal pattern across the CT6 is relatively linear with a dominant west to east pattern of connectivity (**Fig. 19**). The reefs of the CT-SEA consistently come out as a hotspot of larval dispersal connectivity. Indonesia's central role in larval dispersal and ecologically connecting the CT is also highlighted. PNG and the Solomon Islands are further downstream in the larval dispersal pathway, acting primarily as regional sinks for coral reef fish and coral larvae.

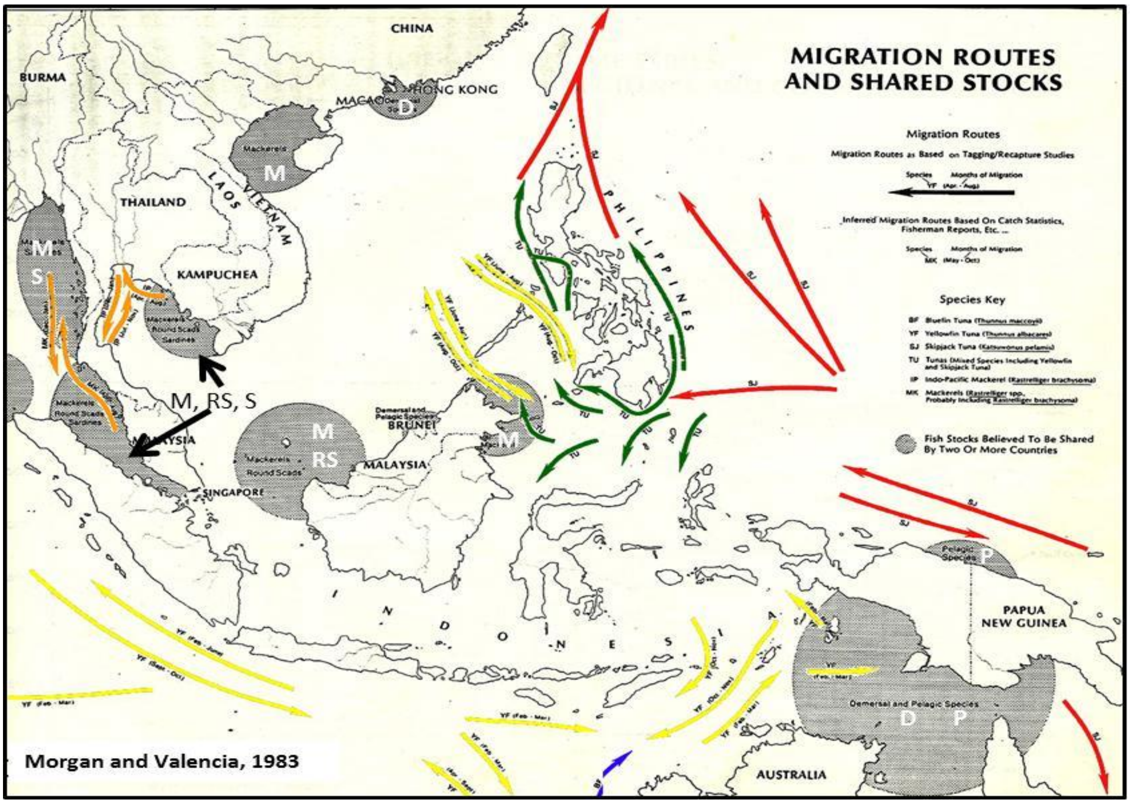
Figure 19: Ecological Association Networks based on the Population Connectivity of Anemone Fish in Indo-Pacific Countries



AUS = Australia, CHN = People's Republic of China, CXR = Cocos-Keeling/Christmas Island, D_SHC = Disputed, South China Sea, FSM = Micronesia, IDN = Indonesia, JPN = Japan, MHL = Marshall Islands, MNP = Mariana Islands, MYS = Malaysia, NCL = New Caledonia, PHL = Philippines, PLW = Palau, PNG = Papua New Guinea, SLB = Solomon Islands, THA = Thailand, TLS = Timor-Leste, TWN = Taipei,China, VN = Viet Nam, VUT = Vanuatu
Darker nodes have higher centrality and the size of an arrow is proportional to the level of local retention of larvae within the region.
Source: Adapted from Treml and Halpin (2012).

Tuna. The archipelagic diversity of habitats in the CT also makes it a prime refuge for juvenile yellowfin and bigeye tuna (Bailey *et al*., 2012b). Tuna 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 CT and are caught at varying stages of development by different countries across the region (**Fig. 20**). Juvenile tuna are caught in the Philippines and Indonesian waters. These are often sold in domestic markets or canned, making their value much less than that of adult tuna caught in the Pacific Islands, often by international fishing fleets from developed countries. Ingles and Pet-Soede (unpublished) term this phenomenon the "Broken Triangle" because of the mismatch of benefits in the tuna fishery vis-à-vis expected fisheries management inputs.

Figure 20: Inferred Migration Paths of Tuna and Shared Stocks in Southeast Asia



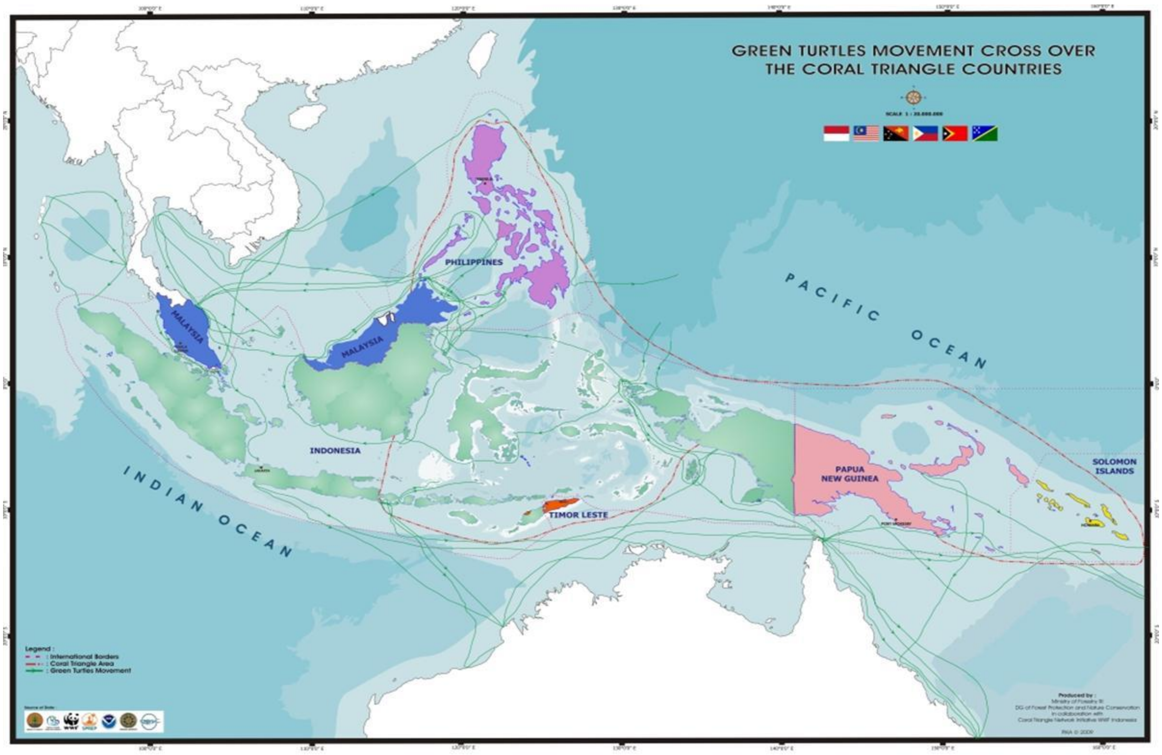
Arrow colors indicate migration paths of different tuna species: red = skipjack tuna, yellow = yellowfin tuna, blue = bluefin tuna, green = mixed tuna, orange = mackerels. Shaded areas indicate shared stocks: D = demersal, P = pelagic, M = mackerels, RS = round scads, S = sardines.
Source: Morgan and Valencia (1983).

Currently, 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 the 266,200 t of tuna caught are juveniles. Per species, the proportions of juveniles per 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 tuna fisheries management in the region.

The coastal habitats of the Philippines, Malaysia, and Indonesia are important feeding grounds for juvenile tuna, while adult and larger tuna species are caught in the Pacific Islands (PNG and the Solomon Islands). Tuna spawning grounds in the CT-SEA need to be protected, and catching of juvenile tuna regulated. This requires support mechanisms that involve the CT6 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 CT (Pilcher, 2009). Olive Ridley turtles nest in Puerto Princesa, 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 (Pilcher, 2009). Marine turtles, such as leatherback and green turtles, migrate extensively across the CT and beyond (Pilcher, 2009; Block *et al*., 2011; Bailey *et al*., 2012a).[34] 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, Indonesian seas, and southeastern Australia, reaching as far as the western coast of the United States (Bailey *et al*., 2012a). Green turtles move across the entire CT (**Fig. 21**). 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 driftnets to ensure the resilience of turtle populations across the CT

Figure 21: Movement of Green Turtles (Chelonia mydas) in and near the CT



Source: http://marinesciencetoday.com/2009/09/04/maps-show-need-for-mpa-for-sea-turtles-in-southeast-asia/

Coral Reefs. Coral reefs and fishery resources in the CT 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 CT 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 CT 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 in order to be regionally effective.

Although coral reefs in the CT are more self-recruiting (i.e., most of the larvae settle close to their source reefs) than dispersing, larval dispersal models still reveal important larval sources and sinks in the region that require a networked and integrated approach to management in order to be regionally effective. Coral reefs in the CT located along country boundaries are most likely close enough to be reliant on each other for larval supply.

Despite being dominated by self-recruitment, centrality in terms of larval connectivity still exists in the CT, with Indonesia serving as an important node connected to most CT 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 CT countries; it must, therefore, set a good example for the rest of the CT6 on coral reef conservation and management. However, since Indonesia also receives larvae from the Philippines and PNG (Kool *et al.,* 2011), these countries

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

must conserve and maintain the ecological viability of their coral reefs in order for Indonesia to sustain its coral reef and fisheries diversity.

The CT6 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 upstream source of genetic diversity for the CT. As the CT is not isolated, management must eventually engage other countries outside the CT.

Three ecologically connected clusters in the CT have been repeatedly cited in larval dispersal studies: (i) Malaysia, Philippines, and Indonesia; (ii) Solomon Islands and PNG; and (iii) Indonesia and Timor-Leste. Therefore, implementing regional fisheries management actions in the CT may be done using these ecologically relevant clusters as a step towards CT-wide fisheries management initiatives.

B. Economic Connectivity: Trade in Fisheries Products

Economic connectivity can take many forms, including trade in goods and services, transportation, currency, factors of production, infrastructure, and institutions. These connectivities exist in the CT, with some links stronger than others. International trade, in particular, allows the movement of goods and services. Goods embody the inputs/factors used in their production and can, therefore, be a proxy in the movement of factors of production. This section focuses on seafood trade among the CT6 and between them and other countries.

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 kg in 1961 to 17.0 kg in 2009 (FAO, 2012). This is, however, still lower than the demand from Oceania, North America, and Europe, whose annual per capita fish consumptions are 24.6 kg, 24.1 kg, and 22.0 kg, respectively. Most of the fish consumed in these developed regions is 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 re-export industries (e.g., fish processing and canning) are also important sources of employment in the CT6 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), where 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 CT countries possess uniformly rich marine biodiversity and fisheries resources, which are reinforced through biological connectivities between them, which also influence fish trading patterns between and among the CT6 and between them and the global markets.

1. Fisheries Trade among the CT6

The CT6 countries have open economies whose fisheries 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 the 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.

Table 17: Fishery Exports and Imports in the CT6, 2007

Countries	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		1
Malaysia	1,563,942	359,848	514,614		33
Philippines	3,209,410	215,023	176,232		5
Papua New Guinea	263,960	143,207	28,355		11
Solomon Islands	31,272	17,282	2,744		9
Timor-Leste	350				
Asia (excluding People's Republic of China)	44,551,175	9,856,804	10,366,289		23
Oceania	1,414,234	830,650	553,310		39

Source: Laurenti, 2011.

Timor-Leste, the youngest nation in the group, has relatively scarce trade data as much of its trade is unrecorded. A very small volume of exports was recorded in 2005 in the form of processed/dried fish (606 kg valued at $2,722), and no official fisheries export was recorded between 2006 and 2010. However in 2012, the country started exporting again (da Rosa, pers. comm., 2012). In 2005, the recorded fishery imports were about 104 t with a total value of about $264,000, composed mostly of processed fish and related commodities (UN Comtrade, 2012). In 2008, fishery imports totaled $249,000 (NDE, 2010).

The volume of trade in fish and fishery products among the CT6 is not large compared to trade with countries outside the CT (**Table 18**). From 2000–2008, there appeared to be a trade surplus for Indonesia and PNG, and a trade deficit for Malaysia, the Philippines, and the Solomon Islands. For the CT6 as a region trading with the rest of the world (ROW), there was a consistent surplus from 2000–2008, which has increased by about 60% or an average of 7.5% increase per annum. Yet, this rate of increase is barely above the world average inflation rate of about 7.3% for that period.[35] Therefore, the value has been more or less stagnant in real terms.

Table 18: Net Value of Fishery Product Trade for the CT6 and with 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)
PNG	5.71	10.98	(0.02)	10.92	12.37	0.00	0.00	0.00	0.00
Philippines	(7.68)	(1.75)	(5.86)	(19.10)	(5.80)	(18.79)	(16.48)	(18.29)	(25.55)
Solomon Islands	0.00	0.00	(0.31)	(0.05)	0.03	0.02	(0.01)	(0.39)	0.00
CT6 with ROW	1,897	1,862	1,870	2,000	2,056	2,115	2,247	2,531	3,043

* Total value from FAO data, including trade of fish, crustaceans, mollusks, and other aquatic animals, but excluding aquatic mammals, crocodiles, caimans, alligators and aquatic plants. Data provided by Stefania Vanuccini, Fishery Statistician (Commodities), FAO FIPS (Fisheries and Aquaculture Statistics and Information Service). Values in parentheses are negative, indicating imports in excess of exports.

Based on bilateral fish trade flows for 2010 from the UN Comtrade database, dependence of the CT6 on each other, in terms of exports or imports, ranges from less than 0.1% (i.e., for exports from the Solomon Islands) to 26.1% (for exports from PNG). The major trading partners in terms of relative contribution to the country's exports or import values are Indonesia-Malaysia and Philippines-PNG (**Table 19**). Almost 20% of the import value for fish in Malaysia comes from Indonesia. However, exports to Malaysia constitute only 2.7% of Indonesia's total fisheries exports. Malaysia also exports fish to Indonesia, contributing 8% to Indonesia' total fisheries import value. Further, the Philippines is a major export market for PNG, comprising a quarter of the total fish export value for PNG. This amount is equivalent to 13.3% of the total fish import value for the Philippines. Overall, the CT 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

[35] Calculated from World Bank inflation database. Source: http://data.worldbank.org/indicator/FP.CPI.TOTL.ZG

from other CT6 countries contribute between 0.2% and 18.2% of total fish import values for a given CT6 country. The CT6 countries comprise at least 10% of total fish import values for Indonesia, Malaysia, and the Philippines. In contrast, as export markets, the CT6 contribute not more than 5% to total fish export value, except for the Philippines and PNG.

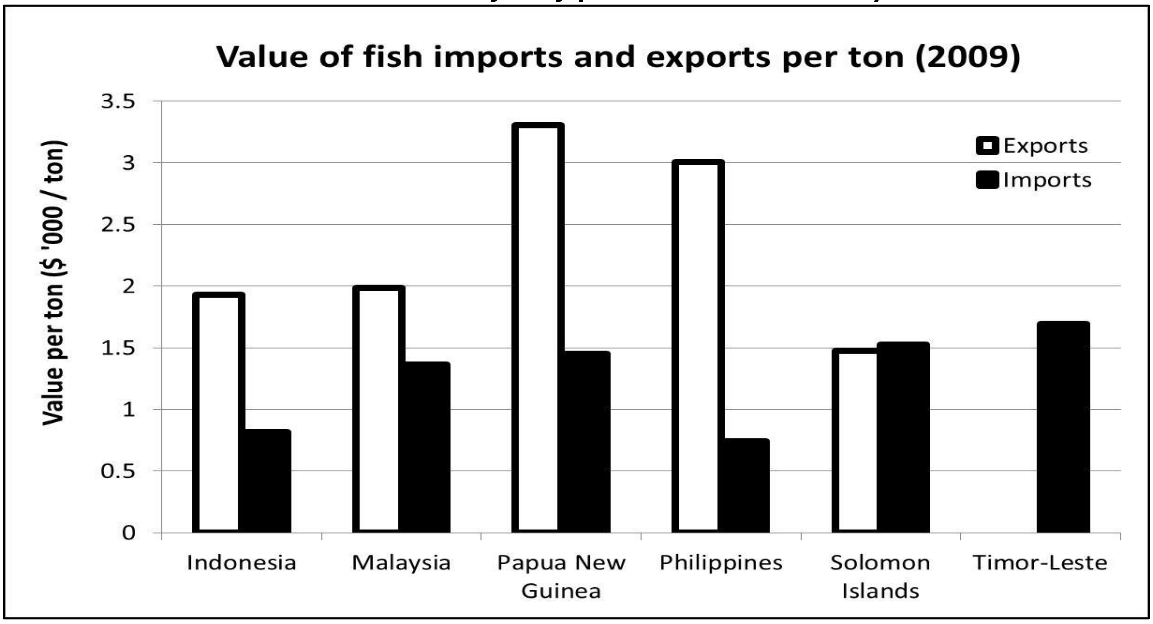
Table 19: Percentage Contribution of Fish Exports and Imports between and among the CT6, by Value*

Partner Countries (Destination or Source)	EXPORTER					IMPORTER			
	Indonesia	Malaysia	Philippines	Solomon Islands	PNG	Indonesia	Malaysia	Philippines	Solomon Islands
Indonesia		4.2	0.3		0.1		18.1	3.4	
Malaysia	2.7		0.2			8.0		0.4	0.2
Philippines	0.2	0.3			25.9	0.3	0.1		
Solomon Islands	<0.1				0.1				
Papua New Guinea		<0.1	<0.1	<0.1				13.3	<0.1
Timor-Leste	<0.1								
% CT6 contribution	3.0	4.4	0.4	<0.1	26.1	10.1	18.2	17.0	0.2

*except for PNG, which is in tons
[a] Export data for processed and frozen tuna and other species based on quantity (t) (Source: Usu, 2011).
Note: Values greater than 10% are highlighted by bold font and grey shading.

The value of fishery trade products per ton relates to the overall quality of fish products traded. The Philippines and PNG export high-value fish products, primarily tuna, with an average value of $3,000–$3,300 per ton (**Fig. 22**). 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 the Solomon Islands, they are almost on par. Timor-Leste showed almost no exports of fish products to other countries.

Figure 22: Value of Fishery Imports (per ton) and Exports per CT Country, 2009 (Includes "fish" commodity only per FAO classification)



Source: FAO Fisheries and Aquaculture Information and Statistics Service

2. Fisheries Trade between the CT6 and Other Countries

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

Table 20: Top Export (and Re-export) Country Partners of the CT6, 2010

CT6 Export Destination	Weight (kg)	Value ($)	Value/weight ($/kg)
Thailand	216,738,5	112,912,9	0.52
People's Republic of China	151,066,8	122,800,2	0.81
Japan	119,201,5	685,059,9	5.75
US, Puerto Rico, and US Virgin Islands	110,391,4	705,879,4	6.39
Singapore	88,759,0	171,200,7	1.93
Viet Nam	50,250,4	96,312,2	1.92
Other Asia, not elsewhere specified	45,522,7	73,608,8	1.62
Hong Kong, China	42,112,2	218,939,5	5.20
Malaysia	41,820,7	45,220,7	1.08
Indonesia	37,668,6	29,378,2	0.78

Source: Data from UN Comtrade

Aggregated CT6 trade, both in terms of quantity and value, increased during 1989–2011 (**Fig. 23**). In 2010, the CT-SEA 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). Six destination countries accounted for 70% of the total export of fish and fishery products by weight from the CT6 (**Table 21**). In addition, Hong Kong, China, a major trading partner for the live reef food fish trade, receives 4% of the total fish products exported by the CT6.

Figure 23: Aggregated Free-On-Board (FOB) Values of Fish Trade from the CT6

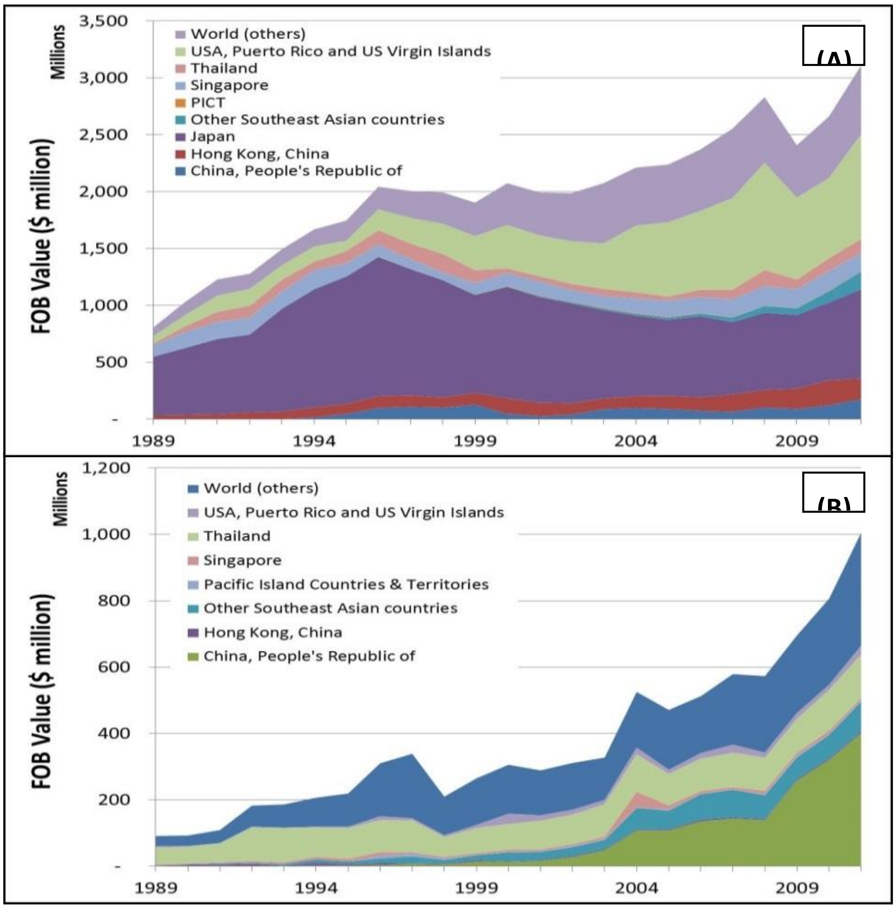


Table 21: Percentage Contribution of Fish Exports and Imports per CT Country with Other Countries, by Value*

Partner Count	EXPORTER					IMPORTER			
	Indonesia	Malaysia	Philippines	Solomon Islands	PNG[1]	Indonesia	Malaysia	Philippines	Solomon Islands
CT	3.0	4.4	0.4	<0.1	26.1	10.1	18.2	17.0	0.2
Outside CT									
PRC	3.7	6.1	3.1			38.4	32.5	21.5	1.9
Japan	28.3	12.6	23.6		7.9	8.9	2.8	9.8	11.6
Other SEA	2.9	6.4	0.6	<0.1	0.6	9.2	9.0	10.5	
Pacific Islands & & Territories	<0.1	0.1	0.9	0.1	5.5	0.5		1.5	
Singapore	3.9	15.2	2.5		2.0	1.2	0.8	2.1	<0.1
Thailand	4.4	3.3	1.9	62.5	3.9	12.9	14.3	0.4	27.3
Australia	0.8	4.4	0.2	0.1	7.7	0.6	1.2	0.2	37.3
Hong Kong	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[2]	2.2	3.1	5.0		3.3	3.8	1.6	16.4	
US	30.5	23.1	20.1	0.2	7.7	1.9	1.0	4.5	
EU	8.4	2.9	15.1	35.7	33.7	0.3	1.5	0.4	
World (others)	6.8	9.2	10.8		1.5	11.8	15.6	14.9	<0.1

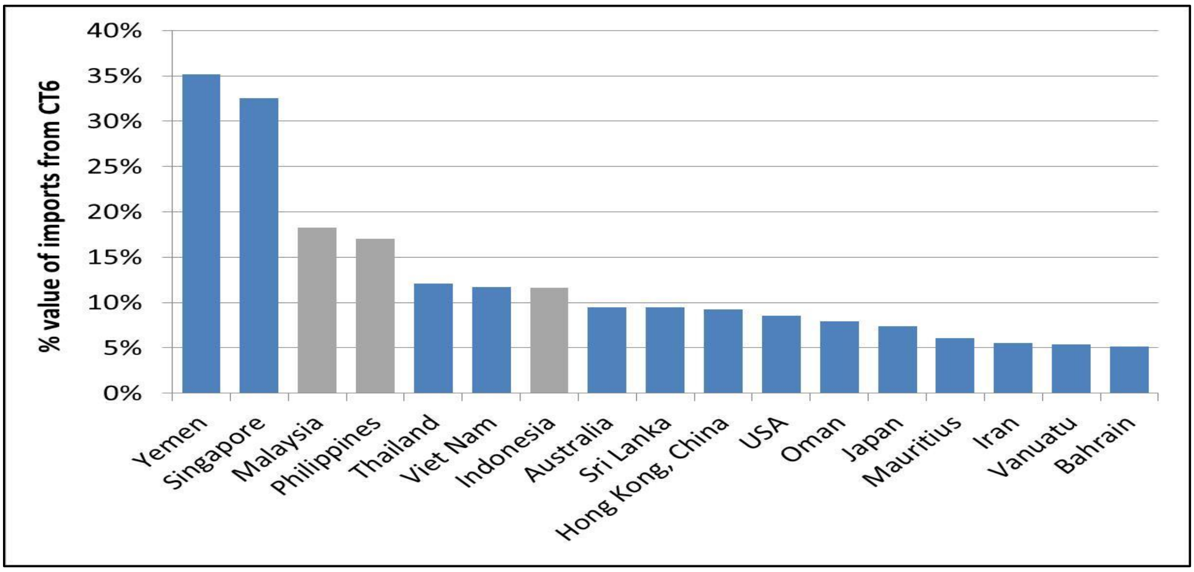
* except PNG, which is in tons.
Note: Values greater than 10% are highlighted by bold font and grey shading.
[1] Export data for processed and frozen tuna and other species based on quantity (tons). Data source: Usu 2011.
[2] "Other Asia not elsewhere specified". This is a classification from the UN Comtrade database; it includes Taipei, China.

In terms of value, three countries (United States of America [USA], Japan, and Hong Kong, China) together account for more than 70% of the total value of exports from the CT6, while comprising only 30% of total weight (**Table 20**). These are the higher value exports from the CT6, i.e., averaging $5–7/kg compared with <$2/kg to other countries. These three countries together with the People's Republic of China (PRC), Singapore, Thailand, and Viet Nam account for about 93% of the total export value and about 86% of the total weight of fish products from the CT6.

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

There are about 17 countries and/or regions that depend on the CT6 for a major portion of their fisheries imports. **Figure 24** shows 17 countries and/or regions where fisheries imports from the CT6 region comprise 5% or more of total imports. At the top of the list is Yemen, where about 35% of imports are from the CT6, followed by Singapore at about 32%. To assess the position of the CT6 countries in seafood exports for various commodity groupings, **Table 22** shows their rankings among the Top 10 world exporters for each commodity group. Only the CT-SEA are among the Top 10 producers in the world. For live fish, Indonesia, the Philippines, and Malaysia are consistently top world producers for several commodities, including fresh live fish, eels, carps, and whole (fresh or chilled) Salmonidae, flatfishes, yellowfin tuna, skipjack and other tunas, and eels. The CT-SEA are also top producers for some frozen seafood categories, including Pacific Salmon, Salmonidae, yellowfin, albacore, longfin, and other tunas, as well as dogfish, eels, and seabass. Note that unlike the live exports, only Indonesia–not the Philippines and Malaysia–are strong players in world exports for frozen seafood.

Figure 24: Countries where CT6 Exports Contribute > 5% of Total Fishery Products Imported, by Value, 2010



Data source: UN Comtrade using the commodity code HS1996.03. Accessed on 6 November 2012.

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

Harmonized Coding System Code	Product Description	Top 10 Exporters (leftmost = Top 1)									
0301 Fish, live	Fish	MY	ES	PH	TH	ID	GR	LK	MM	UK	CN
	Eels	CN	ID	MM	DK	NL	PH	HK	NZ	FR	UK
	Carp	CZ	CN	LT	IR	HU	MY	US	BA	HR	BY
	Fish, except trout, eel or carp	CN	MY	PH	KR	TH	MM	ID	JP	HK	US
0302 Fish, fresh or chilled, whole	Salmonidae, not trout or salmon	NO	PA	ID	MR	MA	TH	IN	TR	GR	FR
	Flatfish, not halibut/plaice/sole	US	ID	UK	ES	FR	NL	IE	DK	EG	PK
	Tuna (Yellowfin)	ID	TH	PH	JP	PA	LK	MV	MX	FJ	FR
	Skipjack, Stripe-bellied bonito	OM	ES	US	IN	FJ	IT	GR	FR	PT	ID
	Tuna not elsewhere specified	ID	VN	MT	ES	HR	FJ	TR	AU	US	PT
	Eels	ID	DK	UK	NL	SE	IR	US	CN	BE	ES
0303 - Fish, frozen, whole	Salmon, Pacific	US	CL	RU	JP	FJ	MR	CA	CN	NZ	ID
	Salmonidae, not elsewhere specified	MR	ID	NO	US	TH	BF	PK	IN	VN	KH
	Flatfish except halibut, plaice or sole	US	PK	ID	RU	NL	ES	KR	IR	IN	EC
	Tunas (albacore, longfin)	US	JP	ZA	FJ	SG	CA	ES	ID	KR	NZ
	Tunas (yellowfin)	KR	ES	FR	PH	CO	MX	TH	ID	FJ	CV
	Skipjack, stripe-bellied bonito	KR	JP	FR	ID	CN	EC	MV	CO	NZ	BR
	Tuna not elsewhere specified	KR	VN	ES	EC	FJ	CN	ID	AU	US	FR
	Dogfish and other sharks	ES	JP	SG	US	PT	NZ	VN	ID	CR	KR
	Eels	US	CN	NZ	CA	IR	MY	TH	ID	DK	IN
	Seabass	MY	HK	SG	NI	BE	NL	TH	US	TR	PT
0304 - Fish fillets, fish meat, mince except liver, roe	Fish fillets, frozen	CN	VN	NO	US	AR	DE	IS	CL	NL	ID
	Fish meat and mince, except liver, roe and fillets, frozen	US	NO	VN	IS	TH	CN	CL	ID	AR	NZ
	Flours, meals, and pellets of fish for human consumption	US	TH	ZA	PK	CN	MM	ID	RU	ES	MY
0305 - Fish, cured, smoked, fishmeal for human consumption	Livers and roes, dried, smoked, salted or in brine	CN	ID	IS	CA	US	DK	NO	HK	MY	VN
	Smoked fish and fillets other than herrings or salmons	TH	ID	DK	PL	TR	CL	NL	PH	CN	EE
	Cod dried, whether or not salted but not smoked	NO	SE	IS	PT	CN	ES	DE	ID	RU	CA
	Dried fish, other than cod, not smoked	NO	TH	CN	TZ	VN	IS	HK	ID	MM	MV
	Herrings, salted or in brine, not dried or smoked	DK	NL	NO	RU	ID	DE	EE	IE	CA	LT
	Fish not elsewhere specified, salted or in brine, not dried or smoked	HK	CA	NO	IS	PK	LV	UK	ID	SE	ET

Harmonized Coding System Code	Product Description	Top 10 Exporters (leftmost = Top 1)									
1603 - Extracts, juices of meat, fish, aquatic invertebrates		IT	CN	TH	US	IN	BR	FR	MY	NL	NZ
1604 - Prepared or preserved fish, fish eggs, caviar	Sardine, brisling, sprat prepared/preserved, not minced	MA	TH	LV	EC	UA	US	EE	ID	PT	CN
	Tuna, skipjack, bonito, prepared/preserved, not minced	TH	PH	EC	ES	MU	ID	CN	GT	VN	NL

Source: UN Comtrade (2012).
* Country codes: Argentina = AR, Australia = AU, Belarus = BY, Belgium = BE, Bosnia Herzegovina = BA, Brazil = BR, Burkina Faso = BF, Cambodia = KH, Canada = CA, Cape Verde = CV, Chile = CL, People's Republic of China = CN, Hong Kong, China = HK, Colombia = CO, Costa Rica = CR, Croatia = HR, Czech Republic = CZ, Denmark = DK, Ecuador = EC, Egypt = EG, Estonia = EE, Ethiopia = ET, Fiji = FJ, France = FR, Germany = DE, Greece = GR, Guatemala = GT, Hungary = HU, Iceland = IS, India = IN, Indonesia = ID, Iran = IR, Ireland = IE, Italy = IT, Japan = JP, Latvia = LV, Lithuania = LT, Malaysia = MY, Maldives = MV, Malta = MT, Mauritania = MR, Mauritius = MU, Mexico = MX, Morocco = MA, Myanmar = MM, Netherlands = NL, New Zealand = NZ, Nicaragua = NI, Norway = NO, Oman = OM, Pakistan = PK, Panama = PA, Philippines = PH, Poland = PL, Portugal = PT, Republic of Korea = KR, Russian Federation = RU, Singapore = SG, South Africa = ZA, Spain = ES, Sri Lanka = LK, Sweden = SE, Thailand = TH, Turkey = TR, Ukraine = UA, United Kingdom = UK, United Republic of Tanzania = TZ, USA = US, Viet Nam = VN

For processed fisheries commodities, only Indonesia is among the Top 10 producers of fish fillets, cured/smoked fish, and fishmeal for human consumption. For prepared seafood, CT6 are among the Top 10 producers in very few commodities. This points to possible opportunities for the expansion of domestic value-adding activities in the CT6 (taking into account production costs and constraints), which can further contribute to employment and income generation.

The CT6 are important in the marine ornamental fish trade. The Philippines and Indonesia were the largest exporters of marine ornamental fish to the USA, each representing over 990 species, and 5.8 and 3.3 million fishes, respectively, in 2005 (Rhyne *et al*., 2012). The Solomon Islands also exports marine ornamental fishes to the US, but contribute only 1% to the total imports of marine ornamental fish by the USA. Four CT countries are sources of corals for the coral trade: the Philippines, Indonesia, Malaysia, and the Solomon Islands. The Philippines leads in terms of volume, but Indonesia leads in terms of value. These four countries accounted for 27% of the volume and 38% of the value of corals imported into the US during 1996–2011 (UN Comtrade data).

C. Governance/Institutional Linkages

This section describes the status of linkages existing among the CT6 and identifies opportunities for them to tap into existing networks or linkages so that they could contribute to the broad goals of the CTI through knowledge exchange and policy standardization. This is essential for resources that move beyond political boundaries.

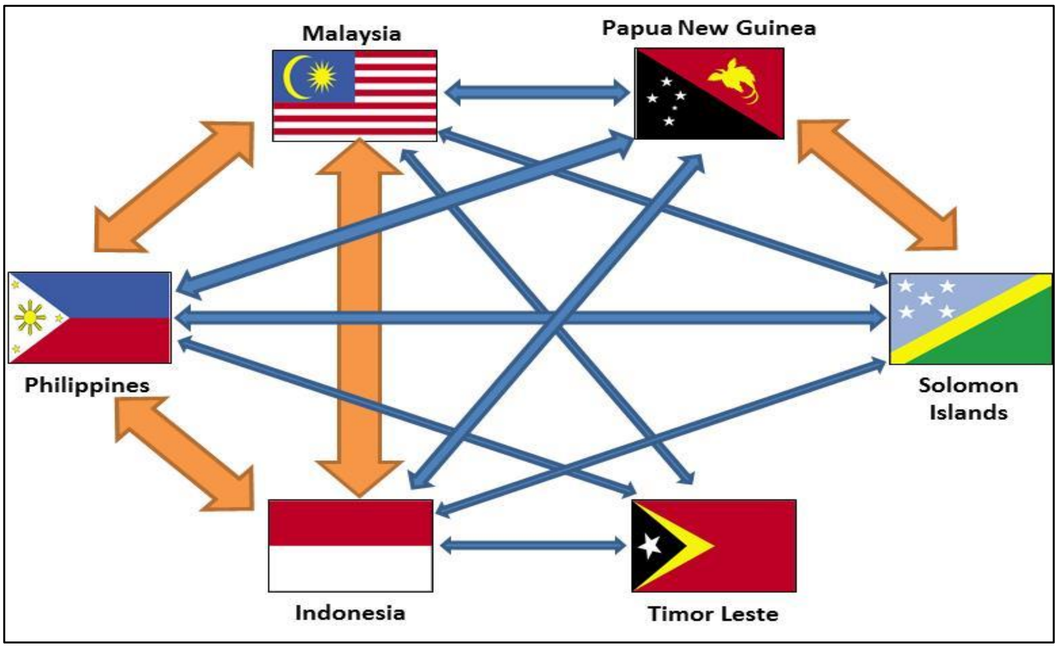
The CT6 are signatories to several binding and nonbinding agreements (Fidelman and Ekstrom, 2012). There are strong regional ties between and among Malaysia, the Philippines, and Indonesia, separate from the Solomon Islands and PNG (**Table 23; Fig. 25**). Timor-Leste, being a new independent nation, is involved in the *Partnerships in Environmental Management 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, three have the highest membership among the CT6. Five of the CT6 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 providing 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 are also signatories to the *Convention on Biological Diversity (CBD)*. 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)*.

Table 23: Number of Multilateral Fisheries-related Agreements among the CT6

	Malaysia	Philippines	Indonesia	Timor-Leste	Solomon Islands	PNG
Malaysia		11	13	2	2	4
Philippines	11		11	2	4	5
Indonesia	13	11		2	2	4
Timor-Leste	2	2	2			
Solomon Islands	2	3	2			9
PNG	4	5	4		9	

Source: Data from Table 23.

Figure 25: Binding and Nonbinding Fisheries-related Agreements among the CT6 Showing Overlaps



Note: Arrow thickness indicates relative number of fisheries agreements between countries. Orange arrows refer to relationships with more than 11 existing agreements.

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, ASEAN and the Asia-Pacific Economic Cooperation (APEC), provide opportunities for integrating the aspirations and vision of the CTI into the 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 in endangered flora and fauna. ASEAN-WEN has external links with enforcement agencies in Australia, PRC, EU, and the USA, and with the secretariats of ASEAN and CITES, Interpol, and the World Customs Organization (WCO). To advance the regional goals of the CTI, several communities within ASEAN are of relevance, including the ASEAN Ministerial Meeting on Agriculture and Forestry (AMAF) and the ASEAN Ministerial Meeting on the Environment (AMME). To scale-up the investment climate in the CTI, the ASEAN Economic Ministers, the ASEAN Finance Ministers, and the 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 (FRWG).

Table 24: Regional Fisheries Institutional/Governance Agreements among the CT6*

Institutional Arrangements		Description	Countries Involved						CT Issues
			INO	MAL	PHI	PNG	SOL	TIM	
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 Centres 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	✓	✓					
		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 Action Plan of Actions for Responsible Fishing	✓	✓	✓	✓		✓	
		SCS: South China Sea	✓	✓	✓				
		SPREP: Secretariat of the Pacific Regional Environment Programme				✓	✓		
	Scientific Networks	**GOFAR:** The Asia-Pacific Group of Fisheries and Aquatic Research	✓	✓	✓	✓	✓		

Note: The last column corresponds to CT-relevant fisheries issues or topics that can be covered by a corresponding agreement.
C – Collaborating non-member (http://www.wcpfc.int/), IUU - Illegal, unreported, and unregulated fishing, LRF – Live reef fish, O – Observer status, INO – Indonesia, MAL – Malaysia, PHI – Philippines, PNG – Papua New Guinea, SOL – Solomon Islands, TIM – Timor-Leste
* Prepared by Ms. Christine Marie Casal (WorldFish Center Philippines); Source: Lymer *et al*., 2010.

APEC consists of 21 member economies including four of the CT6.[36] Together, its members account for over 80% of global aquaculture production and more than 65% of the world's capture fisheries, and the consumption of fishery products in the APEC region is 65% higher than the world average.[37] 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 (OFWG) in 2011, representing a merger of the Marine Resource Conservation Working Group and the Fisheries Working Group. The OFWG announced that it was initiating a mapping study of all fisheries initiatives within the APEC as well as developing a work plan during the APEC Senior Officials Meetings held in Indonesia in February 2013.

The Southeast Asian Fisheries Development Center (SEAFDEC) is an intergovernmental organization established in December 1967 for the purpose of promoting sustainable fisheries development in the region. Its current member countries include Indonesia, Malaysia, and the Philippines. Of interest to the CTI is SEAFDEC's collaborative activity to update scientific information

[36] The Solomon Islands and Timor-Leste are not members.
[37] www.apec.org

and the status of tuna resources in the Sulu-Sulawesi Sea, a priority seascape of the CTI, and its project on Preventing Export of IUU Fishing Products. Very recently, SEAFDEC led the CT6 toward the establishment of a live reef fish forum resulting from a conference held in February 2013 in Bangkok. SEAFDEC's mandates in marine fisheries research and aquaculture may well cover the issues relating to the exploitation of juvenile groupers, wrasse, 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 Southeast Asian countries are more economic in nature, while those among Pacific countries have strong knowledge-sharing components. The Secretariat of the Pacific Community (SPC) and the Fisheries Forum Agency (FFA) are highly technical agencies able to provide sound scientific advice to member countries in the development of their fisheries. FFA, which includes PNG and the Solomon Islands plus 15 other countries of the Pacific, is an advisory body providing expertise, technical assistance, and other support to its members, who make sovereign decisions about their tuna resources and participate in regional decision making on tuna management through such agencies as the Western and Central Pacific Fisheries Commission (WCPFC). The focus of FFA on tuna can be explored further, especially in sustainable financing initiatives such as payment for ecosystem services (PES). The Secretariat of the Pacific Regional Environment Programme (SPREP) has networks on climate change, invasive species, and biodiversity, and can form useful links to the CTI.

A big challenge in the CTI is building stronger relationships within the CT6. While multilateral and bilateral fisheries-related agreements abound among the Southeast Asian countries and among the Pacific Islands countries, agreements between Southeast Asian and Pacific Island countries are few. The CTI is the first non-binding agreement that encompasses all six countries and could serve as a platform for linking the Southeast Asian and Pacific countries in view of their shared unique attribute, i.e., high coral reef biodiversity.

There are opportunities for the CTI to strengthen partnerships with existing institutions, for example, through exchange of knowledge between organizations or standardization of policies and procedures. ASEAN-WEN practices can be extended to the Pacific countries, especially because of the exportation of corals. There are existing organizations involved in tuna, in terms of actual management and supporting science work, that span all CTI countries; however, a purposeful connection should be planned. SEAFDEC has the potential of looking at several important issues, including tuna, live reef fish, and IUU fishing, and has signified interest in engaging with the CT6 in the live reef fish trade.

D. Conclusions

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

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

Aside from exploring opportunities for value addition, a way to increase the trading advantage of the CT6 is to form a bloc to maximize market strength toward greater concentration and standard pricing, niche pricing, and product differentiation. Using the industrial performance framework, the CT6, as the CTI entity providing goods and services to the global market, has advantages over each country acting on its own. Using some parameters that define market structure and conduct, cooperative undertakings via the CTI can increase market strength by agreements on pricing and developing niche markets as well as marketing a range of unique products and services (horizontal and vertical product differentiation), which is possible due to the high biodiversity of fish species found in the region (**Table 25**).

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

Selected Elements of Market Structure and Conduct	Advantages of CT6 Acting as a Bloc
Concentration	Increased market strength with possible agreement on pricing
Product differentiation	Six countries in total boasting of 2,500 species of fish alone and which make vertical and horizontal differentiation highly possible due to enormous biodiversity
Barriers to entry	Agreement on common pricing strategy and common policy will limit entry into overfished areas within national boundaries to control fish supply
Pricing	Agreement on range of pricing and niche pricing, especially for certified commodities
Advertising	Marketing of “CTI” as a brand

The idea of economic integration is not new. ASEAN, in a bid towards economic integration, has identified 11 priority sectors that would accelerate the region’s economic integration by 2010, one of which is fisheries (Pomeroy *et al*., 2008). Aiming to increase intra-ASEAN trade, a number of integration criteria were agreed upon, including tariff and non-tariff barriers, improvement of logistics, rules of origin, and movement of human resources. Accordingly, the fisheries roadmap only considered food safety issues as specific targets towards integration. The ASEAN model can be used as a springboard on which to design a CTI–type integration.

Enhancing trade opportunities among the CT6 can be done by product differentiation, which can involve the production of more value-adding products, with countries participating at various nodes of the supply/value chain. However, an in-depth study on factor prices (e.g., labor, natural endowments, capital) and opportunities for supply/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 inter-regional issues, such as migrating stocks of tuna or trade in live reef fishes, are examples of where institutional linkages can be strengthened and 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. However, although it is the first agreement entered into by all six countries, multilateral coordination mechanisms and agreements on fisheries and coastal and marine resource management the region already exist, albeit fragmented, in the CT region. 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 human well-being. Furthermore, as knowledge on fisheries in the CT is largely scattered, increased interaction and collaboration between and regional fisheries agencies and organizations could ensure that the regional goals of the CTI, particularly for fisheries, are achieved.

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CHAPTER V
SUBSISTENCE FISHERIES IN THE CORAL TRIANGLE

A. Overview

Globally, the numbers of small-scale fishers and their fisheries are "too big to ignore"[38] (Chuenpagdee, 2012). Béné (2003) and FAO (2010) count more than 34 million active fishers, while Berkes *et al*. (2001) estimate over 50 million fishers supporting at least 450 million dependents. In contrast, large scale fisheries employ around 500,000 fishers (Béné, 2003; FAO, 2010). Small-scale fisheries contribute half of global fish supply for human consumption (Jacquet and Pauly, 2008). While commercial fisheries contribute $3 billion annually to the CT6 (Hoegh-Guldberg *et al*., 2009), two 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 the term "small-scale fisheries," depending on the points of view and socioeconomic dimensions interpreted in different national and local contexts (Johnson, 2006). However, small-scale fisheries are usually contrasted with large-scale fishing operations using technological parameters. Tokeshi *et al.* (2012) state 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) proposes the values of social justice and ecological sustainability as defining small-scale fisheries. WWF, in an unpublished report entitled, "Small boats, big problems," argues 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.[39] 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.*"[40]

Small-scale fisheries include artisanal, recreational, and subsistence fisheries, the last mentioned being 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, n.d.). 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.

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[38] 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.

[39] http://wwf.panda.org/?132341/small-boats-big-problems

[40] http://www.fao.org/fishery/topic/14753/en

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

- "*Small-scale fisheries: fisheries undertaken using small-scale boat, gear and equipment.*
- *Artisanal fisheries: fisheries undertaken mostly for home consumption using selected traditional gear.*
- *Subsistence fisheries: fisheries 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). The *Fisheries Act No. 31/2004* defines an artisanal fisher as anyone who relies on fishing as his livelihood to meet his 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) characterizes Indonesia's artisanal fisheries as one-day fishing, using traditional fishing gears and/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 (39.13%), gill nets (27.79%), and traps (10.89%).

In 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 seabass, lobsters, shallow-water reef fish, nearshore pelagic fish, mangrove crabs, freshwater prawns, and a range of other reef and coastal fishes (Kailola, 1995). Fish account for 94% of consumed animal protein in the Solomon Islands with nearshore subsistence fishing meeting 60% of consumption needs (Weeratunge *et al.*, 2011).

In Malaysia, Teh *et al*. (2011) estimate that Sabah's small-scale catches have been undervalued by up to 225% from the early 1990s to the present. In the Solomon Islands, 82% of the population belongs 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 to 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, local food security, and in the Pacific Islands, to incomes as measured through GDP. In a recent review of benefits from Pacific island fisheries, ADB (2009) estimated that the contribution of subsistence fishing to GDP was quite large in a number of Pacific island countries. Overall, about 30% of the GDP contribution from the fishing sector in the region comes from subsistence fishing (Gillett, 2011). In the Solomon Islands and PNG, coastal subsistence fisheries were estimated to contribute 82% and 84% of the overall fisheries production from coastal areas, respectively, in 2007 (Gillett, 2011). Gillett (2009) estimates the value of reef fish in the 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 to be $21 million.

Employment and livelihood statistics also highlight the significance of this sector. In the Pacific islands, 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, namely: they are under-reported, under-valued (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 non-existent.

To contribute to the knowledge of subsistence fisheries in the CT6, this study employed various methodologies to assess the importance of subsistence fisheries in contributing to incomes, employment, and food security. In Timor-Leste and the Solomon Islands, the approach was to implement surveys to obtain primary information on subsistence fisheries and dependency levels. In the

Philippines, a workshop involving national agencies and local governments with mandates for fisheries data collection was organized. The approach was to assess the current methodologies for data collection for the subsistence fisheries sector by examining how national agencies undertake their collection protocols and determining how data collection is undertaken at the local level from information supplied by representatives of local governments.

In Timor-Leste, a survey of capture fisheries households in the Liquica District (Suco Dato) was conducted in August 2012 with the objectives of (i) obtaining the level of dependency of households on fisheries-related activities for their livelihoods at the village level; and (ii) enhancing 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[41] by functioning as a "pilot test" for the larger census and providing training to MAF staff. Timor-Leste's NPOA, particularly Target Number 4, which supports livelihood and food security programs using the 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.

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

B. Fisheries and Reef Interactions in the Solomon Islands

1. Background

The Solomon Islands has a dual economy: (i) the formal or cash economy; and (ii) the informal or subsistence economy, which includes the vast majority (85%) of the population. Agriculture, fishery, forestry, and small-scale income-generating activities form the bulk of the subsistence economy. The literature emphasizes the importance of subsistence fisheries in the Solomon Islands in contributing to food, nutrition, employment, and cash incomes. Yet, estimates of production from the sector and related statistics are mostly guesswork (FAO, 2010). Household income and expenditure surveys provide a "best estimate" of catches associated with the subsistence sector (FAO, 2010). 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, does not get properly counted except through household expenditure surveys.

Coral reefs play an important role in the lives of Solomon Islanders both for subsistence and income generation. Reef fish contribute significantly to the protein intake of the population (Bell *et al*., 2008) and are also becoming an important source of income with increasing access to markets (Green *et al*., 2006). Some variation in food fish populations among major islands is attributed to a 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 with small human populations.

This report contributes to the understanding of the importance of subsistence fisheries in the 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 the Solomon Islands

Gillett (2010) lists six categories of fisheries utilization in the Solomon Islands: coastal commercial, coastal subsistence, offshore-locally based, offshore-foreign-based, freshwater, and 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

[41] Households that engage in fisheries-related activities including aquaculture, capture fisheries, fish processing, and marketing.

(Table 26). Finfish, bêche-de-mer, trochus, green snail, and mangrove wood are among the commodities coastal fishers harvest (World Bank, 2000). Data from FAO Statistics for production of fish, crustaceans, and mollusks yield estimates up to 2010 but do not provide the same disaggregation.[42] The average volume in 2008–2010 was around 30,000 t, which conforms to the offshore locally-based fishing figure in **Table 26**, since offshore foreign-based fishing, though conducted in Solomon Islands waters, is reflected in the countries of the fleets.

Table 26: Marine Fisheries Production in the Solomon Islands, 2007

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

Source: Gillett, 2010.

There are no figures on the extent of fishing activity in the country, let alone subsistence fishing. However, it is estimated that nearly half of all women and 90% of men in most rural households fish (Weeratunge *et al.*, 2011). Nearly all households in coastal villages are involved in coastal fishing activities. Thus, all villages in the Solomon Islands that are rural and coastal are "fishing communities." The number of subsistence fishers in the 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 SPC as 5.2 people, the minimum number of subsistence fishers was derived. It is estimated that a minimum of 88,000 people engage in fishing if it is assumed that is one household member is a fisher.[43] 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 to the total population but more so when compared to fish workers or those who are formally employed. In 1999, an estimated 3,367 people were engaged in paid work in the fisheries sector, amounting to 12.1% of total paid employment in the Solomon Islands (Weeratunge *et al.*, 2011).

3. Fish Consumption

The 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 kg and 31.2 kg in the rural areas, while the national average was 33 kg (of which 90% consisted of fresh fish). However, these figures may be an underestimation (Weeratunge *et al.,* 2011) since Pinca *et al.* (2009) estimated the annual per capita fish consumption to be in the range of 98.6–110.9 kg.

Among urban households, expenditure on fish (for food consumption) is slightly higher than the national average of 14.5%, while rural households spend 13% (**Table 27**). Rural households rely on their own production or that of their kin/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 the 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 (Sulu *et 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), Tulagi (Central Islands Province), Kirakira (Makira), and even as far as Bougainville markets for nearby communities (Boso *et al.*, 2009).

[42] www.ftp.fao.org

[43] This is a conservative estimate.

Table 27: Fish Utilization in the 2005-2006 Solomon Islands Household Income and Expenditure Survey

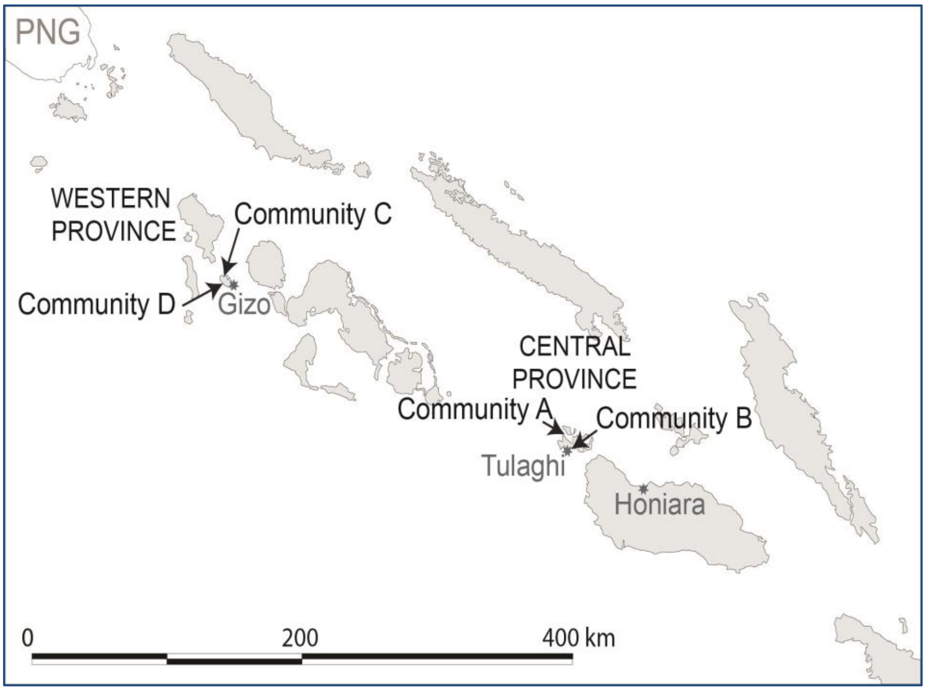
Source	Urban %	Rural %	National %
Food consumption expenditure on fish	16.90	12.98	14.49
Home production[44]	4.81	55.89	36.90
% households in self-employment and related businesses engaged in sale of fish and other seafood	9.34	16.44	15.93

Source: HIES (2006) and Sulu *et al*. (in press)

4. Case Study: Economic Value of Subsistence Fisheries

The ADB Knowledge Management Project and the WorldFish Center in the 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 collection in four communities was undertaken in the Western and Central Provinces. Two communities were selected in the Western Province, representative of those with no known wild coral harvest (non-coral trade communities) (Fig. 26). Two communities were selected in the Central Province, representative of 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) (**Fig. 26**). All four communities harvested coral for the production of lime, which is consumed while chewing betel nut. The reef environments include mostly fringing reefs, with some deeper and barrier reefs. Using Google Earth, the total reef area was estimated for each site, resulting in 0.13 km^2 and 0.5 km^2 for the Central Island Province reefs, and 7.0 km^2 and 0.82 km^2 for Western Province reefs.

Figure 26: Western Province and Central Island Province Study Sites in the Solomon Islands



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

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

Table 28: Number of Interviews Undertaken in Case Study Communities on Goods and Services from Coral Reefs, and Population Parameters

Communities	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

The Total Economic Value (TEV) framework was used to estimate direct, indirect, and non-use values of corals. Direct use values refer to products and services directly consumed (extractive and non-extractive); 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 type of food goods (including fish, clams, crayfish, shells, seaweed), construction materials (sand, rubble, and coral boulders), and trade goods (e.g., trochus, shark fins, coral lime, curio coral, aquarium coral, and other reef ornamentals) they collect from the reefs. The respondents were further queried on the quantities collected and importance of each good for their food and cash need. Community-level economic values of coral reef goods were derived through FGDs with community leaders (men and women) at the time of the interviews.

Median values were derived per respondent per year for food and other uses of coral reefs then adjusted based on the percentage of respondents that harvested these goods and the estimated number of fishers/people dependent on reef goods in each of the communities. By necessity, assumptions were made to calculate this value. A key assumption was that only one adult member of the household (>14 years of age) is engaged in the extraction of goods, with the exception of the coral aquarium and curio trades, where the actual number of people engaged in these activities within each community was used to calculate the economic value.

The main reef-derived food goods across all study communities were fish, clams, seaweed, trochus, lobsters, and shells (mainly spider conch (*Lambis lambis*) and stromb shells (*Strombus sp*.). In general, food goods derived from the reef were ranked equally important for consumption in the household and for sale, although some food items (e.g., shells) were mostly for household consumption.

Coral reefs provide, on average, SI$18,000– 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 yield an average subsistence and cash value of SI$9,600– SI$43,000 per respondent per year across the four study sites.45 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.

Table 29: Value of Food, Material, and Trade Goods* at the Four Study Communities, SI$ per Year per Respondent**

Item	Coral Trade Communities		Non-coral Trade Communities	
	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

* Reef fish values are shown separately.
** Exchange rate in November 2011 was US$1 = SI$7.28.

[45] Exchange rate was US$1I=$7.28 in November 2011.

The value of reef fish ranged from SI$3,400 – 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 (US$41– US$145 million per year).

Table 30: Total Value of Reef Fish for Subsistence and Cash at the Study Sites

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

*Value is SI$ per respondent 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 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 to 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 upwards 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, a province of Indonesia), much of the fisheries infrastructure was destroyed, including fishing vessels and gear (Kalis, 2010). A 2001 survey estimated that there were only about 800 seaworthy vessels, whereas in the last record in Indonesia before the turmoil, there were 20,027 wooden canoes and 160 motorized vessels (McWilliams, 2003). It was only in the mid-2000s that systematic development of the fisheries sector was possible in Timor-Leste, including the recording of fisheries data.

In 2005, it was estimated that there were close to 5,000 fishers in the 151 fishing centers in the country. By 2009, the number was estimated to be about 6,360 people, with about 2,177 non-motorized 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).

In 2010, Timor-Leste conducted a national population census, but fisheries was not included although a range of agricultural indicators were covered by the census. The government is planning a fisheries census in the near future and has begun collecting some information. Data gathering at key landing sites has started, using a standardized method and unit of measurement (kg); a boat census was completed in October 2012 with FAO support. It is hoped that in one or two years, additional reliable information will be available through these efforts.

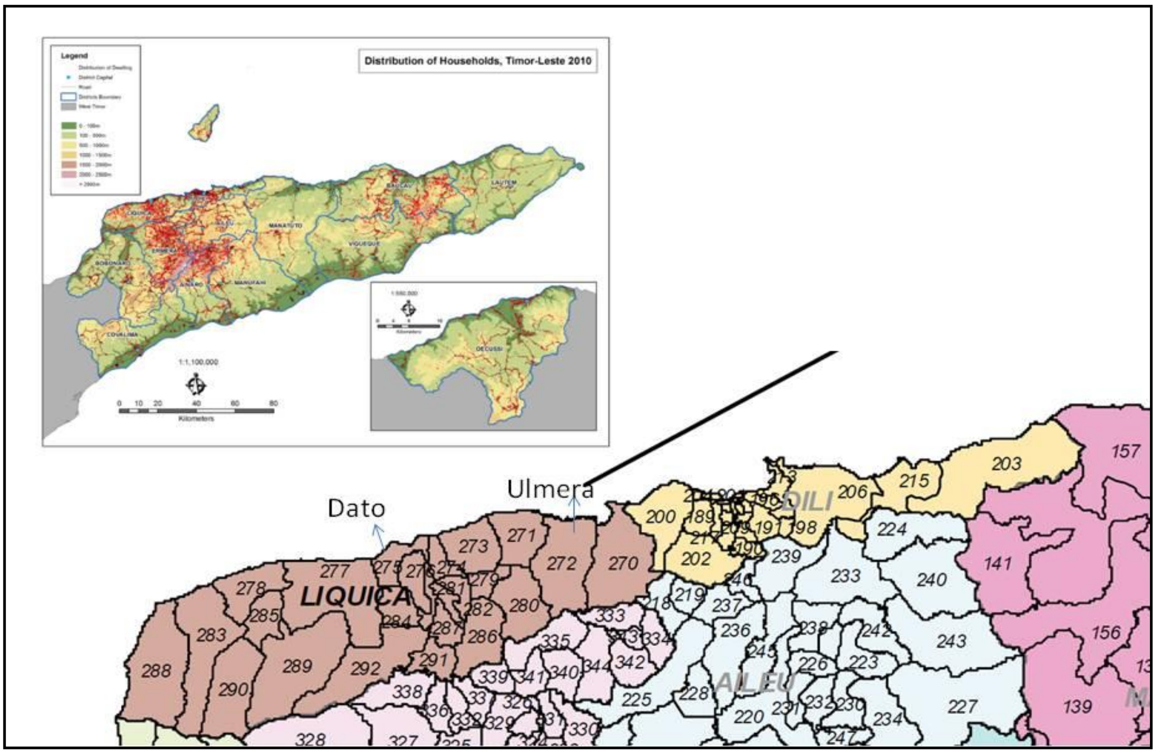
For the present report, a survey of capture fisheries households in the Liquica District (Suco Dato) was conducted in August 2012 with the objectives of (i) obtaining the level of dependency of village households on fisheries-related activities for their livelihoods; and (ii) enhancing the capacity of the MAF to design, plan, and implement a national fisheries household census. The survey was funded by the ADB KM Project and was administered by UNIQUEST (Australia). The results of the survey are summarized below.

[46] www.indexmundi.org

1. Survey of Fishing Households

A household survey was conducted in May–July 2012 in two coastal villages, Leopa and Camalehohoru Aldeia, in the Liquica District, Dato subdistrict, about 50 km west of Dili, the capital (**Fig. 27**). In 2010, the total population of Dato was 8,109 in 1,221 households (average household size, 6.7 persons). Of this total, Camalehohoru and Leopa had 5,075 persons in 764 households, for an average household size of 6.6 persons (NSD and UNFPA, 2011).

Figure 27: Timor–Leste and the Survey Area



Source: NSD and UNFPA, 2011b

From a list of more than 100 fishing households involved in capture fisheries, 32 were randomly chosen. These 32 households had a population of 274 people, for an average of 8.6 persons per household, which was higher than the Dato subdistrict average (6.7 persons/household) and the national average (5.7 persons/household).

However, the educational attainment of the survey households was better than the national average. There were fewer people who had never attended school and a higher proportion with primary or pre-primary level education. A higher proportion of households also owned the house they lived in, and the condition of their houses and facilities was better than the national average.

All 32 households conducted fishing as one family/household unit, and nearly all had wooden boats, ranging from medium-sized (5–7 m) or small (4 m or less) non-motorized boats to medium or small motorized boats. One household had a large motorized boat. All boats and gear were owner-operated; some were obtained through government grant programs. All households, except one, used gill nets and hooks and lines for fishing. Five households used spears, and three used bottom longlines.

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 in May, June, and July 2012 were $1,282, $175, and $216, respectively.[47] The average total cost of fishing in the May–July 2012 period was $263, leaving an average net income of $1,410 for three months, or about $470 per month.

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

However, there were wide income differences among fishers – from a loss of $266 to a high of $1,248.

A large proportion of the households surveyed (24 or 75%) also depend on other agriculture-related activities, including crop planting and livestock keeping. However, 53% of the households said that fishing is 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 surveyed respondents' catch was primarily for sale, with a portion for domestic/own consumption; and (ii) the households were integrated into the economy, since much of the fishing and disposal was via market channels.

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

Table 31: Categories and Characteristics of Fisheries in Timor–Leste

Characteristics	Subsistence Fisheries*	Survey (August 2012)		Regional or National[a]	
Size of fishing craft/vessel and engine	None or small (5-7 m; <10 gt) usually non-motorized	62% of households operate small or medium (up to 7 m) non-motorized boats; 50% of households operate small or medium motorized boats (up to 15 hp); only 3% (one household) uses a large boat (>7 m)	✓	78% of vessels are without engine (2009)[b]; in a regional survey in five districts, 82% use wooden non-motorized 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	NA	Mostly gill net and hook and line; virtually all manual gears		Out of an estimated 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% use beach net, 34% use fish net, and 31% use gill net. [c]	
Fishing unit	Individuals, family or community groups	All households conduct fishing as a family unit; almost all 1-2 people	✓	Nationally, except for the large-scale fishers in Atauro Island, most conduct fishing as a family unit (2009)[b]; 76% fish in small groups of 2-5 fishers; 23% 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% rented; 4% borrowed.[c]	✓
Type of commitment	Mostly part-time/ occasional	More or less 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;[c] 54% spend less than 6 hrs/trip; 22% spent 6-12 hrs; 16%, 12-24 hrs; 6% spend two or more days at sea.[c]	

[48] The main income sources were growing garden fruit and vegetables and raising livestock.

Characteristics	Subsistence Fisheries*	Survey (August 2012)		Regional or National[a]	
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.	✓	NA	
Disposal of catch	Primarily household consumption but some local barter and sale	Primarily for sale and some for household consumption; 63% sell at fishing centers; 31% sell on the roadside, on the beach, at local market, etc.		A regional survey in five districts found that 27% fishers sell their catch at a local market.[c]	✓
Utilization of catch	Fresh or traditionally processed for human consumption	Almost all sold or consumed fresh	✓	A regional survey in five districts showed that 60% of catch are sold as fresh product,[c] 36% process a small portion of catch before selling (traditional processing method);[c] outside of Dili area and Atauro Island area, very limited use of ice for preservation.[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]	

* FAO and WorldFish Center (2008).
a Source: Kalis (2010).
b National description based on Kalis (2010).
c Regional description (for 5 districts) based on Amsat (2011).
Note: A check mark (✓) indicates that the characteristic is typical of subsistence fisheries.

2. Community Dependency

In addition to a survey of capture fishing households, a village census of all households within a prescribed area was conducted to enumerate those households with at least one member engaged in capture fisheries, aquaculture, or salt harvesting. The village chosen was Aldeia Mane Mori in the Ulmera District of Timor-Leste. Mane Mori is a small village is near Dili with a narrow mangrove-lined beach. Households in the community engage in a variety of ocean-related activities, i.e., capture fisheries, seaweed farming, aquaculture (grouper growout, crab collecting and growout), 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 (33), or 56%, had no members engaged in capture fisheries or aquaculture. About 18% had at least one member of the household engaged in capture fisheries, and about 25% in aquaculture. Four households (7%) had at least one member engaged in both capture fisheries and mariculture. Therefore, community dependence on fisheries was high overall—about half of the households were dependent on livelihood sources in 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 that fisheries was their main source of income, although they could not attribute percentages to either aquaculture of capture fisheries. They indicated, however, that aquaculture provided a more stable source of income than fishing.

In addition to selling fish, most households retained a portion of the catch for their own consumption. The survey was conducted during the low season in fish harvesting, when most of the catch was consumed domestically—on average 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 were relatively high. Seaweed harvesting was a more stable source of income. However, the cost of living in Timor-Leste is quite high, and income from fisheries is spent to buy meat, vegetables, and rice, which most households do not produce themselves. One small household of five in Mane Mori earned $200–$ 400 every two or three weeks from selling their harvested seaweed in Dili. Yet, the family lived in a very modest dwelling with dirt floor and thin walls, and their children were poorly clothed.

3. Conclusions

First, the survey results and data from secondary sources indicate the significant dependence of Timor-Leste households on fisheries, although not as high as expected. Fishing households have a variety of 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 due to the 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 there, either directly or indirectly through wholesalers. However, the surveys in Dato and Ulmera 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, it is clear that even the smallest fishing unit provides the opportunity to earn cash from the sale of fish at the community level.

Third, the small-scale fishers of Timor-Leste do not have large debts to capital owners, such as seen in Indonesia, for example. Fishers generally own their fishing assets as well as a house and some land. Therefore, while little can be concluded about the poverty level of fishing households (vis à vis households in other sectors), asset ownership and availability of capital allow for some production and cash earnings. However, the key question is whether earnings will allow further investments in productive assets, education, and skills improvement, or are just enough to satisfy day-to-day needs. Full details of the survey and village census are in **Appendix 2**.

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

1. Background

A workshop on “Improving Fish Catch Statistics Collection in the Philippines with Focus on Subsistence Fisheries,” was held in February 2012 in the Philippines to assess the status of data collection in the subsistence fisheries sector and develop a methodology suitable for adoption by local government agencies. The workshop, organized jointly with the WorldFish Center, involved national agencies in charge of collecting and analyzing fisheries data, namely: BAS, BFAR, and NFRDI. The objectives of the workshop were to: (i) develop a methodology that local governments can apply in the estimation of fisheries statistics from the subsistence sector; (ii) increase awareness among participants regarding the importance of the contribution of the subsistence sector to production, food security, and household incomes; and (iii) recommend policies that will institutionalize the collection of fisheries statistics, including those in subsistence fisheries. The workshop was intended to help generate a better assessment of the contribution of subsistence fisheries to production, livelihood, and food security – information that has not been accurately recorded due to existing data collection protocols, divergent collection methods of national government vis-à-vis local governments, and the spatial and temporal spread of fishing activities. By determining the strength and weaknesses of national fisheries collection and the initiatives of local governments to monitor fishing activities within their jurisdiction, it was thought that some convergence and enhancement of methods could be achieved, including data sharing and streamlining or harmonization of methods.

1. Data Collection by National Agencies

Two national agencies collect fisheries statistics: BAS and NFRDI. BAS is assigned to consolidate all forms of agricultural statistics, including those for fisheries. In a bid to improve data collection in the municipal sector, 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 is ultimately used by BAS in determining an "expansion" factor. There are also cases when the management of a landing center changes hands or becomes inoperable. As of 2010, BAS monitored 8,779 municipal fish landing centers, which provide estimates of municipal fish catch (BAS, 2010). BAS hires contractual data collectors to implement the questionnaire. The data collectors are stationed at the landing sites and conduct the data collection with selected informants such as fish traders, fishers, fishing boat operators, and fish brokers.

NFRDI is the fisheries research agency of government. The data collected by NFRDI is 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 the generation of 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.

2. 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 questionnaires distributed during the workshop, the minimum data collected by LGUs include fisher population/profile and population/profile of municipal fishing boats. LGUs also collect gear information and fish catch. Data collection is done for the following reasons: (i) fisheries management; (ii) development of new regulations; (iii) submission to other offices (although not explicitly required); (iv) compliance; (v) grant/project proposal preparation; (vi) taxation; (vii) budgeting; and (viii) publication.

At the workshop, the information shared by the LGUs on their data collection protocols varied depending on the fisheries activities in their respective areas, the level of awareness concerning importance of coastal resources, and the capacity of the LGUs to embark on a monitoring scheme. Some municipalities (such as Lubang) reported that no data collection existed in their municipality prior to receiving technical assistance from Conservation International (CI). Thus, there were no records of numbers of fishers or fish catch; however, the LGU monitors access fees paid by commercial fishers fishing in their municipal waters. In Taytay, Palawan which has a long history of live reef fish trade, catch and trade data have been monitored since 2000. In addition, the LGU keeps track of expenditures on the trust fund which was set up in 2007 for enforcement and MPA management. In Zamboanga, a node for the sardine fishery, there is interest in the monitoring of fish catches, especially in relation to the impact of the closed season that was 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, but not entirely foolproof, way to collect data using *Bantay Dagat* or coastwatch patrols. *Bantay Dagat* volunteers are paid to collect information on fish catch, but the data collected were observed to be inaccurate. Lastly, Calauag 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 the Fisheries and Aquatic Resources Management Council (FARMC) database. In order to enhance 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 FARMC members, local councils, *Bantay Dagat*, *Sangguniang Barangay* (village council), NSAP, LGU, BAS, and BFAR.

[49] Fish landing centers serve as sampling units in the conduct of production surveys for municipal fisheries.

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

All of the participating LGUs comply with fishing boat registrations and use of auxiliary invoices (**Table 32**). Most of them implement fisher and gear registration, but only two of the eight municipalities represented in the workshop monitor fish prices. There is also no systematic monitoring of fish catch for the municipal sector, let alone for the subsistence sector, except if volume of fish traded is noted upon the issuance of auxiliary invoice.

Table 32: LGU Fisheries Monitoring System

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

3. Elements of Subsistence Fisheries and Estimation of Economic Contribution

The workshop agreed on a definition of subsistence fisheries and determined the key elements and sources of data based on existing knowledge and practices on the ground and what is known in the literature (**Table 33**).

Table 33: Eight Components of Subsistence Fisheries in the Philippines

Parameter	Subsistence Fisheries Elements	Source of Data
Size/type of vessel	Fishing done with or without boat, thus includes gleaning; if boat is used, 3 gt and below, usually non-motorized; if motorized, size of engine is 10 hp 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 levels	Below food threshold	DSWD through the Community Based Monitoring System and National Household Targeting System (NHTS); National Statistical Coordination Board NCSB)
Disposal	Combination of family consumption/ returns on investment	Partially available from the National Stock Assessment Program (NSAP)
Fishing ground	Municipal waters	Municipal fisheries registration
Technology	Hooks and lines, barriers and traps, gillnets, spear guns	Municipal fisheries registration

Based on the above, 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 non-motorized. The municipal fisher's boat weighs up to three gross tons and below and it runs at a maximum of 10 HP and below. He/she mainly relies on fishing and his 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…"*[51]

[51] Workshop Report on "Improving Fish Catch Statistics Collection in the Philippines with focus on Subsistence Fisheries." Manila, Philippines, 20-21 February 2012. ADB Regional Assistance for Regional Cooperation in Knowledge Management, Policy, and Institutional Support to the Coral Triangle Initiative (TA 7307-REG).

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 or 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 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.

Table 34: Economic Implications of Subsistence Fisheries

Subsistence Fisheries 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/yr 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 (PhP35.30)[c]	• Value of fish consumed at household level is 22% of daily food poverty threshold of $3.95 or PhP162[c] • Value of fish consumed at household level is 16% of minimum wage rate for agriculture sector workers outside Metro Manila, i.e., P225 or $5.50 per day[c]

[a] Estimated at 0.48 kg/fisher/day (Muallil *et al*., 2012); 10% retention assumed.
[b] BFAR, 2011.
[c] At an exchange rate of US$1=PhP41.

It is not difficult to appreciate why problems in data collection occur at both the national and local levels. The nature of fisheries data is such that they are highly variable and disparate, and this occurs in virtually all coastal areas that are not regularly monitored. At the field level, difficulties of securing data can be traced to the (i) lack of funding and personnel; (ii) lack or absence of a dedicated system for data collection, storage, or analysis; and (iii) location of villages, many of which have 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 FAO's characterization of the subsistence fisheries (underreported, economically undervalued, notoriously difficult to manage, and not fully considered in the development dialogue), this report contends that subsistence fisheries in the CT6 are largely undefined and vaguely understood. In the 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 under valuation of the subsistence fisheries in the CT6. Food goods derived from reefs across four study sites in the Solomon Islands have an average subsistence and cash value of SI$9,600– SI$43,000 per respondent per year, with fish being considered the most important reef good. Although this study provides quantitative data for only four rural villages, it is estimated that the subsistence and cash value of reef fish ranges from SI$300–

SI$1,000 million per year or US$41– US$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 to be about 200,000 t or 16% of total municipal fish production from the marine fisheries 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 proportions 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. In the case of subsistence fisheries, however, there is no demand for data by policymaking institutions. Aside from the BFAR, which is the main user of data, other institutions may, in future, influence data collection by BAS. Such agencies include those with in poverty reduction and/or nutrition, 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 user 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, identification of 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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CHAPTER VI

FISHERIES VALUE RETENTION IN THE CORAL TRIANGLE FOR HIGHLY TRADED COMMODITIES

A. Introduction

Except for Timor-Leste, all countries in the CT are engaged in the global trade of fish and other aquatic products. The designation of 200-mile exclusive economic zone (EEZ), enhanced modes for quicker air transport, and improvement in technologies for the storage of fish have pushed seafood trade to higher levels. In 2011, the total trade in seafood products generated by the CT6 totaled $3 billion dollars[52] for the export of tuna, live reef fish, aquarium/ornamental fish, and invertebrates such as sea cucumbers, corals, and shells. From the aquaculture sector, seaweeds and shrimp are the main exports of the CT6.

The economic theory of international trade is that, in general, any country that engages in trade will be better off. However, during the last decades it has become apparent that there are also losers, and that policy decisions can influence how the gains are distributed (Gudmundsson, Asche, and Nielsen, 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 CT, several value chain analyses have been performed. For example, Muldoon and Johnston (2007) applied a spreadsheet model that incorporates risks and probability of attaining risk levels for various stages of the market chain and explains why value distribution is seemingly unfavorable to the fisher. They showed that the fisher earns a maximum attribution of value of 15%; the export subsector earns 25%–55%; the import subsector, another 15%–25%; while the retailer/restaurateur makes 35%. In the Philippines, studies paint different pictures. Pomeroy and colleagues (2005) estimated gross revenue distribution among the catchers, traders, and local governments in the Coron/Busuanga area in Northern Palawan and concluded that the fishers earned more than 80% of the value. Padilla and colleagues (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 the CT6, Brewer (2011) applied value chain analysis for coral reef fishes in five provinces of the Solomon Islands. In addition, there are specific studies dealing with particular segments of the chain, such as relationship between incomes and imports of live reef fish in Hong Kong, China (Si, 2005), regional and local-scale dynamics (Scales, Balmford, and Manica, 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, the value chain is more of a buyer-dominated one 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 the producers or the suppliers. When the chain is perfectly linked, the value changes are communicated efficiently and vice-versa.

[52] Source of basic data: comtrade.un.org/db.

This chapter reviews value chain studies done for countries in the CT, 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.

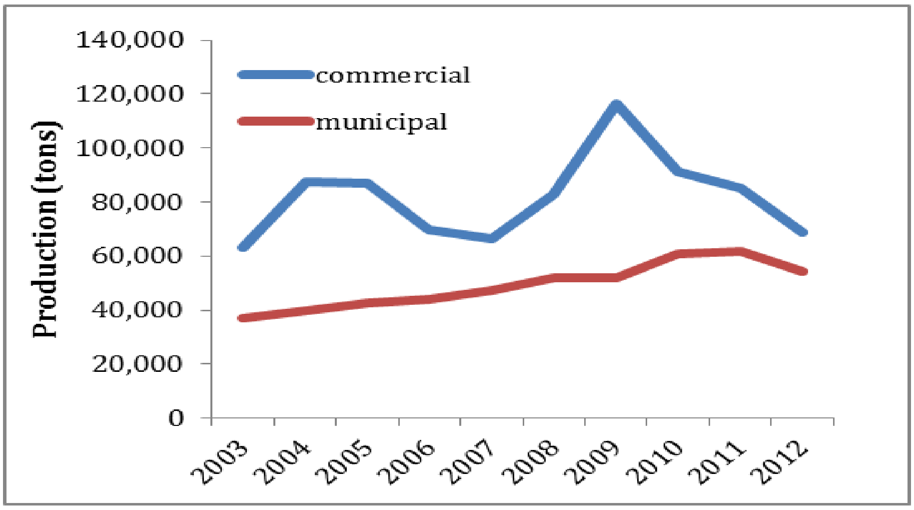
B. Tuna Value Chains in Mindoro Straits and Lagonoy Gulf, Philippines

1. Overview of Tuna Fisheries in the Philippines

Tuna fishing has long been practiced among Filipino fishers, especially in southern Philippine provinces such as Davao, Zamboanga, and Cotabato. 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 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.[53] At its peak, production of yellowfin tuna from General Santos accounted for 69% of total national production in 2009.

Exploited by both the commercial and municipal fisheries sector, tuna, specifically yellowfin, accounts for 10% of the country's total fisheries production (including aquaculture), which was almost 5 million t in 2012. From 2008–2012, the commercial and municipal sector averaged 89,999 and 56,000 t, respectively (**Fig. 28**). The commercial fisheries production showed a drop after reaching a peak of almost 120,000 t in 2009, and was followed by consistent annual declines, suggesting that tuna production from General Santos was the main driver in this subsector.

Figure 28: Production of Yellowfin Tuna, Philippines



Source : BAS, 2012.

Monitoring of catch per unit effort (CPUE) for yellowfin tuna by the General Santos City handline fishing fleet over the period, 2006–2011, showed a decrease from 2007 until end-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 in the hope of obtaining better catch rates. From 2009 onwards, the same decline in CPUE was observed for the purse seine fleet operating in General Santos, while catches of ringnets remained stable.

Tuna remains one of the Philippines' main fisheries exports, which also include seaweeds and shrimps. In 2009–2011, tuna ranked first among 10 major exports, contributing an average of 100,000 t/yr and, despite the drop in share from its peak in 2009, tuna still accounts for almost half of

[53] www.mindanao.com, 29 September 2009.

the volume of fisheries exports (BAS, 2012). From 2009–2011, tuna yielded an average of P15 billion in export earnings.

2. Tuna Handlining in Mindoro Straits and Lagonoy Gulf

Two tuna value chains were studied in the Philippines: the first in the municipalities of Sablayan and Mamburao in Mindoro Occidental, namely; and the second, the Lagonoy Gulf tuna fishery in 15 municipalities in the provinces of Albay and Camarines Sur in Bicol province. In 2011, data were collected through household surveys and costs and returns surveys, supplemented by FGDs in Mindoro Occidental and Lagonoy. Validation workshops were organized in Mindoro in September 2010 and in Lagonoy Gulf in February 2012. Both studies were supported by WWF-Philippines in a bid to enhance sustainable tuna fishing, improve transparency and traceability, and develop niche markets in Europe.[54] In both studies, the objective was to determine how much of the total value of tuna is retained by the fisher relative to the other participants in the value/supply chain, 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 in Mindoro and Lagonoy are shown in **Table 35**. The Lagonoy Gulf fishery is a larger tuna fishery, and CPUE is at least twice that in Mindoro. A census of handline boats yielded a total of 2,663 handliners, including fishers from other municipalities of Mindoro (Rizal, Paluan, Calintaan, and Santa Cruz) as well as 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 is probably due to the variety of handline types being used for big tuna, small tuna, dolphin fish and those using multiple handlines.

Table 35: Basic Production Parameters Relevant to Tuna Value Chain Analysis for Two Localities in the Philippines

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

[1] Olano et al., n.d.
[2] Bradecina, 2011
Sources: Cost/returns survey, FGDs, and on-site workshops.

The duration of a fishing trip is six to seven hours in Lagonoy and three to five days in Mindoro. Since Mindoro is closer to an international airport (Manila) and the fish could reach the exporter within 24 h, tuna caught in Mindoro usually end up being part of the country's exports. In contrast, more than 70% of tuna landed in Lagonoy Gulf are sold locally.

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

- The peak season for tuna is December to March when each boat would catch, on average, 200–300 kg, or about five to six pieces of fish weighing 50 kg each.
- Production levels during peak and lean seasons vary depending on where fishing takes place in Lagonoy Gulf takes place.
- Boats with four fishers operating for two days have a lean season production of 50 kg per fisher/trip, and a peak season production of 100 kg.[55]

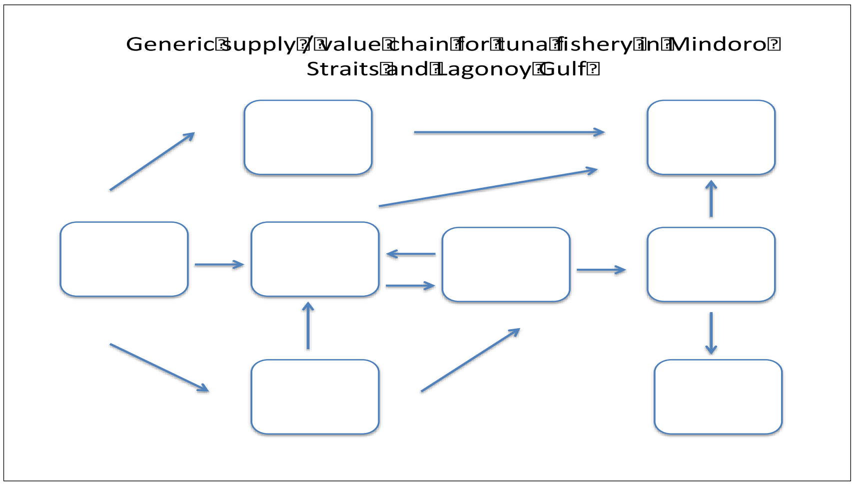
[54] The studies on tuna are part of a three-year conservation program being pursued by WWF-Philippines through support by the Danish International Development Agency (DANIDA) under the Coral Triangle Network Initiative.
[55] Data collected by WWF prior to the consultation yielded an annual average catch of 17.5 kg/fisher/trip.

- Lean season catches could be as low as one piece of tuna weighing 30–35 kg.

3. Characteristics of Supply/Value Chains for Tuna

The value chains in the Mindoro and Lagonoy tuna fisheries are similar (**Fig. 29**), although the former is geared towards the export market, while more than 70% of tuna in Lagonoy 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/retailers can have prior selling arrangements with fishers or they can bid for the catch. Middlemen, referred to locally as *casas* ***or*** *consignacion,*[56] provide another node in the supply chain. Their play roles in the financing of fishing operations, grading of fish, and transport to the exporter. Tuna of Grade "A" are transported to the exporters' processing facilities. The "rejects" find their way to the domestic markets through wholesalers/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 can reach the exporter within 10 hours.

Figure 29: Generic Supply/Value Chain for the Tuna Fishery in Mindoro Straits and Lagonoy Gulf



Value Chain Participants and Roles. The fisher mainly provides labor inputs (before, during, and after the fishing activity) and expertise that depend on the time spent at sea and in preparing the fishing implements.[57] Oftentimes, the participants in the value chain assume multiple roles, owing to the knowledge gained in the fishery and sometimes also due to build-up of sufficient capital. In both Mindoro and Lagonoy Gulf, many *casas* reported starting out as small stall owners/retailers. Vertical integration occurs both ways, i.e., bottom-up and top to bottom. In the case of Mindoro, 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 either (i) itinerant vendors, (ii) wholesalers or retailers, or (iii) *casas* or entrepreneurs. Tuna destined for the domestic market, either the proximate local markets or bigger markets in the metropolis, reach the consumer through itinerant vendors, who sell fish in their communities or through retailers with market stalls.

Tuna destined for the export market are inevitably coursed through the *casa* due to the grading function, since only Grade A tuna are qualified for export. The 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, the 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 (**Fig. 30**). The grader is paid Php5/kg or roughly

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

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

Php250 for a 50 kg tuna. There is a need for a better understanding of the parameters for grading tuna.

Figure 30: Slivers of Flesh Indicating that the Tuna has been Graded

Photo credit: John Manul, WWF-Philippines.

The *casa* assembles, cleans, re-ices, and packs the fish in wooden crates before it is transported to the retail market or to the exporter. A more important role performed by the *casa* 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 Php100,000 or $2,500.

Often, the *casa* funds handline operations but may also request financial assistance from exporters. It is also common for the *casa* to nurture personal relationships with the handline fishers and extending other forms of financial assistance 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 the *casa* sometimes pays the fisher lower than usual prices. However, there are also instances when the fishers would opt to endorse their catch to another *casa,* despite receiving financial assistance or having had a longstanding 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, 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 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 in order to maintain its freshness. It is then vacuum-packed and placed in a giant ice chest where the temperature is maintained at 0^{o}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 the 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. Quality of the 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 study, prices received by handliners are determined by *casa* operators, who base their offers on the prices offered by the exporter. Ultimately, the price offered is based on the grades assigned to the tuna. There are instances, however, when the *casa* would just offer a standard price even prior to grading, which is often an average price for Grade A and Grade C. This attitude reflects risk taking among *casa* operators. At the time of the study, a "straight pricing without grading" was Php120/kg while the price for Grade A tuna was PhP160/kg. The *casa* can also vary the prices offered to fishers depending on whether the fisher has an outstanding debt, i.e., a lower price can be offered to someone with a debt.

In the Lagonoy study, prices received by fishers ranged from Php90–Php100, corresponding to the lean and peak seasons, respectively. The range is quite narrow for those targeting the domestic market. Fishers targeting the export market may avail of a wider price range due to the product differentiation introduced by the grading process. Grade A tuna can be bought from the fisher at Php140–Php150. The price mark-up of the *casa* and retailers is narrow at Php10– Php20. The range of buying prices for consumers reflects the changing patterns of demand. In the Lagonoy fishery, the buying price for tuna is also influenced by the production of other fishes, especially those caught by ringnets.

4. Fisher's Share of Value

To determine the value retention at the fisher level, the price at which the end consumer purchases the tuna is used as the final value. Since the objective is to assess, through supply/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. In particular, the study supported by WWF-Philippines ascertained how sustainability initiatives at the fisher 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 the interview with a Manila-based exporter for tuna sourced from Mindoro; the same pricing scheme was utilized for Lagonoy. The price is the contract price of the wholesalers/supermarket chain in Europe and not the price to consumers.

Table 36: Comparison of Value-adding Contributions and Margins($/kg) of Three Segments of Participants in the Supply/Value Chain for Tuna in Mindoro and Lagonoy Gulf

Segment of Value Chain	Price	Value Adding	Value Adding + Buying Price	Selling Price	Margins
Mindoro					
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
Lagonoy					
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

Note: The reports submitted to WWF-Philippines used Peso values. All numbers were converted at the exchange rate of $1 = PhP43, the average rate during the study.

As a first step, 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, etc. The Mindoro survey also sought information on fixed costs, such as taxes, licenses, and insurance as well as marketing costs, such as auxiliary invoices, landing fees, and commissions, but 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 icing, thus diminishing the quality of tuna.

The average cost to produce a kg of tuna in Mindoro and Lagonoy was estimated at $1.23 and $1.59, respectively (**Table 36**). Higher average production requires more ice inputs, thus, the higher cost for Lagonoy handliners. Since there is no "buying price" for tuna, the difference between the selling price and the value-adding amount constitutes the profit or the margin. The selling price differs between Lagonoy and Mindoro, with a higher margin for the former. It should be recalled that the export market is still a nascent one in Lagonoy, and fishers earn substantial profits even when selling in domestic markets. The role of the *casa* is, therefore, limited with respect to exporting; thus, there is lower value addition for *casa* operators in Lagonoy.

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, at the minimum. This is due to 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 the grading, which is done rather quickly.

Of the value of $17, which is the ultimate value reflective of the consumption of tuna by foreign consumers, 43% is for value addition and 57% constitutes the profit margin. Value addition is equivalent to the costs expended by the participant in order to catch, grade, clean, process, transport, and distribute tuna, and 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 and Mindoro. In terms of contribution to value addition, exporters account for >75% of the value, while fishers contribute 17%–21%. *Casa* operators contribute <5% of the value and is less in Lagonoy than in Mindoro, owing to the number of *casa* operators (and hence, greater competition) and the less developed export sector in Lagonoy. In Mindoro, the bulk of the margins is cornered by the exporter, and the amount is greater than in Lagonoy.

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 receiving 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 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 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 registration of boat, gear, and person. Likewise, compliance with sustainability standards in the use of hooks and fish aggregating devices (FADs) can be rewarded through better prices. At present, the onus of traceability and sustainability lies with the exporter, and hence, their margins are greater.

Apart from the distribution of margins, it is also relevant to determine whether the tuna handliner is financially better off than if he is engaged in another form of employment, here symbolized by the average wage rate. Looking at the net returns arising from three types of grading of tuna and prevailing average catch rates for the two municipalities, net returns for an ordinary crewmember is greater than the average wage rate for both municipalities if the tuna is given a Grade A.[58] 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 reckoned with. Based on information from www.mysupermarket.co.uk, a value of $43.94 was used for one kg of tuna loin.[59] 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.

[58] 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 wherein 1/3 is assigned to the captain, and the remaining 2/3 is again divided into three, which is again divided among the captain and the remaining crewmembers, which, in the analysis is assumed to be three persons.

[59] The prices are current and may differ from the prices during the time of the studies.

C. Live Reef Fish Value Chains from Taytay, Palawan

1. Overview of the Live Reef Fish (LRF) Trade

Trade in LRF is 30,000 t/yr, concentrated in Hong Kong, China, and southern PRC from 20 countries in Southeast Asia and the Pacific (Sadovy *et al*., 2004; Muldoon and Johnston, 2007). While tuna comprises less than 1/20 of the global fish trade, LRF fetch a handsome return of $400 million–$1 billion (McGilvray and Chan, 2001). Hong Kong, 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% is from aquaculture growout of wild seed, and the remaining amount through full cycle culture.[60]

Trade in LRF has evolved over the years. In the 1970s, many of the live groupers in Hong Kong, 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, this had extended to the Maldives, PNG, Fiji, the Solomon Islands, and other Pacific islands. By 2009, the sourcing of live reef food fish by Hong Kong reached more than 50 countries and territories, according to WWF.[61] Scales, Balmford, and Manica (2007) measured the expansion away from Hong Kong at the rate of 100 km/yr during the 1970s, increasing to 400 km/yr 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 study is the leopard grouper (*Plectropomus* spp.), which is the preferred species of hook-and-line fishers (**Fig. 31**). 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 appear consistent with Hong Kong's import figures of around 1,000 t/yr for leopard coral grouper from the Philippines. The LRF trade is worth at least Php1 billion per year, which includes other species of grouper enumerated previously.

Figure 31: The Leopard Coral Grouper, Plectropomus leopardus, locally known as "suno"in Palawan

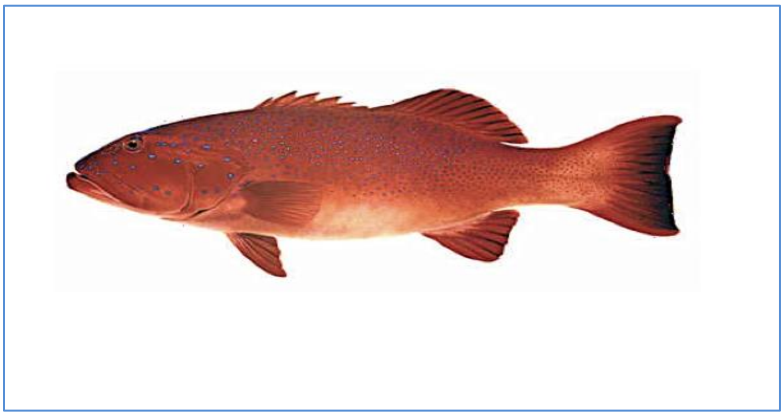


Photo credit: Lory Tan, WWF-Philippines

Table 37: Volume and Value of Exports of Palawan LRF for Food, 2003–2007

Year	Reported Volume (t) of LRF Shipped out of Palawan	Approximate Gross Value (PhP million) based on Landed Price of PhP1,800/kg in Manila
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

Source: Pontillas *et al*., n.d.

[60] At the time of writing, this is true only in Taiwan.
[61] Allen To; www.gaiadiscovery.com.

Palawan supplies at least half of the Philippine production destined for the LRF market. Around 16 of its 23 municipalities are documented as LRF sources. Five 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 Tawi Tawi, Eastern Samar, and Surigao del Norte.

The 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 were: (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 for, and high prices of, LRF due to increasing incomes in importing countries, such as Hong Kong; (iii) stringent price structure based on size of fish; and (iv) more efficient transport of LRF, fuelling greater demand.

Evidence of overfishing may be gleaned from the Calamianes case, which has a long history of LRF trade. Decreasing catches, export volume, and mean size of *P. leopardus* are indicators of overfishing (Padilla *et al.*, 2003) as are the increasingly long distances travelled 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 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 Palawan Council for Sustainable Development (PCSD) has concluded that the Palawan live reef fishery is unsustainable, estimated MSY to be around 186 t/yr, far below current production levels, and acknowledged that urgent measures need to be put in place (Pontillas *et al.*, 2007).

At its peak in 1997, the annual trade in LRF amounted to about 50,000 t at the retail end. By 2002, the volume of trade 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, Balmford, and Manica (2007) tracked 19 source nations for LRF and observed that 10 countries 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 as well as the vertical integration of the supply chain and the resulting ambiguity/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 the fishery to overexploitation. Fishers would rather catch juveniles and fatten these in cages than risk catching larger fish (bigger than 1 kg/pc 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, the shippers have started establishing buying stations and the trade has evolved into an integrated capture/ranching activity. The roles of the 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. 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/value chain.

2. Description of the Study

Addressing the issue of sustainability in the LRF 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 the LRFT is in support of developing and implementing policies on EAFM, which is Goal 2 of the CTI RPOA. 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 due to their strategic role in the LRFT at present. Taytay has the most number of producers and cagers, comprising 64%

and 70%, respectively, of the total number for the province of Palawan. Quezon's LRF industry is a developing one; thus, they can map out LRF strategies using the experience of Taytay and of Coron, which was an important player in the past. This report also recognizes the present 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 MPAs that cover spawning aggregations now totaling 100 ha under the management plan, and imposition of minimum size limits for groupers entering the trade.

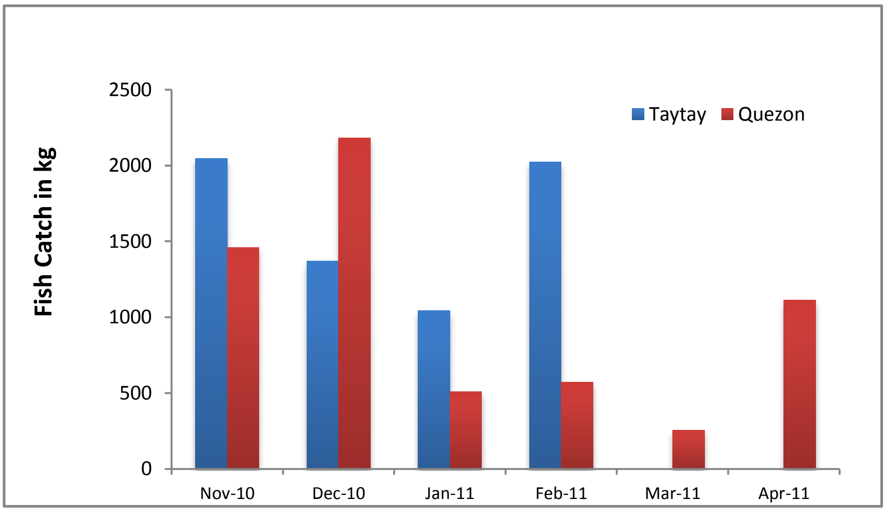
WWF conducted several research studies covering the LRFT, starting with a status report (Cantos *et al*., n.d.), catch and effort monitoring (Palla and Gonzales, 2010), and an income survey report (Cola, n.d.), which contributed to the development of the *Sustainability Plan for the Municipality of Taytay,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

For this supply/value chain study, a mini survey was conducted in both Taytay and Quezon, comprising hook-and-line fishers and cagers who were also previously surveyed for the income profiling (Cola, n.d.). Complementary to the income survey implemented by WWF, data verification was done by WWF research assistants in February 2011, with a few key informants who collected specific cost information. In Taytay, the villages of Talacanen, Pularaquen, and Biton were included as part of a mini key informant interview (KII). The respondents were asked about costs/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. Additionally, three exporters were surveyed in Quezon. Price data for leopard groupers and substitute species, as well as import data from Hong Kong, were provided by Allen To of WWF-Hong Kong.

3. Overview of LRF Fishing in Taytay and Quezon, Palawan

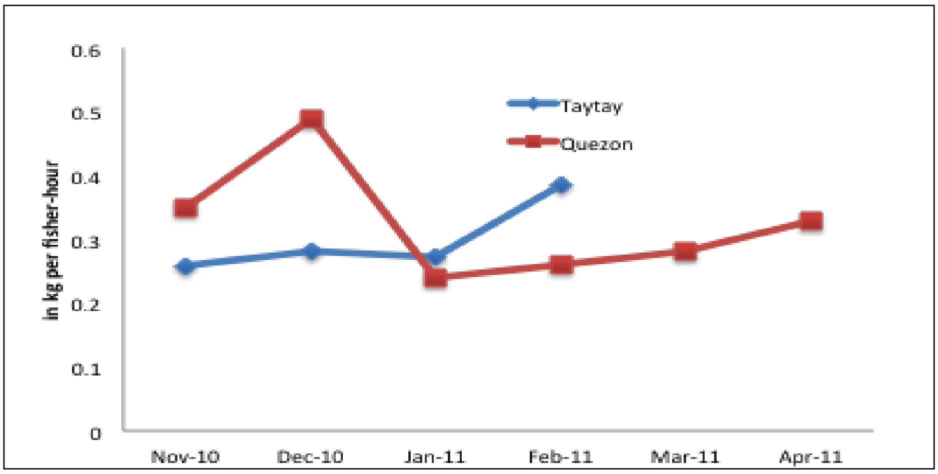
Based on catch and effort monitoring conducted by Western Philippines University from November 2010–February 2011, catches of handlines operating in Taytay and Quezon, Palawan were compared (Palla, n.d.; Palla and Gonzales, 2010). Fish landing surveys were conducted at the major landing sites in Biton, Paly and Casian Islands, and Poblacion, Taytay, while the monitoring for Quezon focused on Alfonso XIII. Average monthly catch for the monitoring period was 1,015 kg for Quezon and 1,600 kg for Taytay (**Fig. 32**). Fishing effort, measured in 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. Monitoring data indicated that the number of fishers in Taytay peaked in October 2010 (763 fishers), then started to drop from November 2010 onwards, and increased again to about 600 fishers in February 2011. The spike in production and fishing effort towards 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.

Figure 32: Comparison of Catches of Simple Handlines in Taytay and Quezon, Palawan from November 2010 – February 2011



Overall, the CPUE for handlines in both municipalities was similarly valued, i.e., 0.30 kg/fisher-hour in Taytay and 0.33 kg/fisher-hour in Quezon (**Fig. 33**). The earlier work of Cantos *et al.* (n.d.) estimated CPUE for leopard coral grouper at 199 g/fisher-hour, less than what is indicated in this study. Groupers comprised an average of 28% of the catch in Taytay and 3% in Quezon, indicating the relatively "young" LRF fishery in Quezon. Catches of other species constituted more than 90% of the handline catches handlines in Quezon and only 62% in Taytay. Catches of invertebrates contributed roughly 10% in both towns. Based on monitoring conducted by Palla and Gonzales (n.d), good-sized groupers comprised 19% and 30%, respectively, of live fish in Taytay and Quezon. Undersized groupers comprised 60% of the catch in Taytay but only 7% in Quezon. Oversized fish seem to be more abundant in Quezon, contributing more than 60% of the catch.

Figure 33: Comparison of CPUE of Simple handlines in Taytay and Quezon, Palawan



4. LRF Supply and Value Chain in Taytay, Palawan

The municipality of Taytay has the highest number of LRF fishers (>2,500 fishers) in Palawan, almost half of whom use hooks-and-lines (also referred to as handlines)(**Table 38**). According to the draft *Sustainability Plan*, there are more than 300 fishers still engaged in compressor fishing, which is usually associated with cyanide. **Table 38** also shows the number of cagers and traders as well as the number of accreditations by PCSD. The actual numbers vis-à-vis the official numbers from PCSD show a huge discrepancy.

Table 38: Actual and Estimated Number of LRFT Supply Chain Participants, Taytay, Palawan

Supply Chain Participants	Estimated Numbers	Location	Source
Fishers	• 2,500 fishers in Taytay, but 886 are LRF fishers using hooks-and-lines • >300 LRF fishers in Taytay using compressors • 105 LRF fishers in Quezon	Palawan	Cantos *et al.*; Cola *et al.*, Matillano (pers. comm., 2012)
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*; Matillano (pers. comm., 2013); 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	CEA
Importers	56	Hong Kong	Allen To and Hong Kong Chamber of Seafood Merchants (pers. comm.)
Wholesalers	90 (including fresh and live fish)	Hong Kong	Fish Marketing Organization, Hong Kong
Retailers	1,250 seafood restaurants; 800 seafood restaurants selling LRF	Hong Kong	Openrice.com; McGilvray and Chan (2002)
Consumers	7.1 million	Hong Kong and entire PRC	www.indexmundi.com

Caging is more prominent in Taytay compared to 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. PCSD refers to both fishers and cagers as "producers".

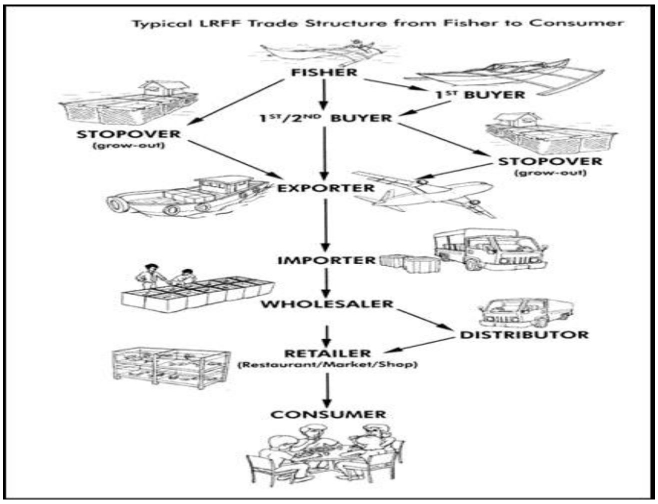
Traders are usually agents of Manila-based exporters. The cagers in Taytay and Quezon habitually do business with Young Marine Products (YMP) and GB Company. These exporters have fielded traders in various parts of Taytay and Quezon, even in the island villages, to be close to the source. Exporters are also affiliated with importers and wholesalers based in Hong Kong – an evidence of vertical integration in the industry.

There are an estimated 56 LRF importers in Hong Kong, based on information provided by Allen To (pers. comm.) and gleaned from the records of the Hong Kong Chamber of Seafood Merchants (HKCSM), the live fish importers' trade association. As shown in **Table 38**, there may be 800–1,250 seafood restaurants in Hong Kong which sell LRF.

Value-adding Activities per Supply Node. A simplified representation of the supply chain is provided in **Figure 34**, 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 is discussed based on Chan (2000) and is also contained in the WWF Consultancy Report (Trinidad, 2012) .

Fisher. 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 as well. He/she may or may not finance the fishing operations, which include the cost of fuel, food, cigarettes, and bait. Aside from hook-and-line, speargun, 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, two to four fishers, but as many as 12 fishers join the trip, and when this happens, each brings his own bait. Quezon fishers use a hooks-and-lines with accessories called "*cristalet*" shell (lure) and chicken feathers. An average fishing trip lasts for five days (total travel time and actual fishing). In good coral reef areas, fishing takes an average of only one hour; in areas where coral reef cover is not as good, fishing time would be 4–8 hours.

Figure 34: Participants and Roles in the LRF Supply/Value Chain



Fisher – catch fish
Trader – conversion of fish to cash
Stopover (cagers) – feeding, rearing till good size
Assemblers – Traders– agents of exporters; prepare fish for transport
Exporter – prepares fish for export
Importer – receiver of fish in HK, with distribution channels
Wholesaler - wholesaling
Retailer - markets to restaurants

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

Cagers. Cages in Palawan can be submerged, hanging, stationary, or floating. Hanging or floating cages are preferred because these allow the cagers to move the cages 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 three- to four-month period, as well as capital, which is used in the construction of cages and operational expenses like feeding the fish. Cagers describe a process akin to acclimatization, which occurs before the actual growout stage. They set up makeshift cages adjacent to the boat or inside the boat so as not to disturb the fish. After the acclimatization, growout commences. The cager may utilize his/her own labor or pay for the labor of other people (caretakers), especially to ensure that no theft occurs. At the end of the growout period, the cager arranges for transport to the holding facility of the buyer/trader.

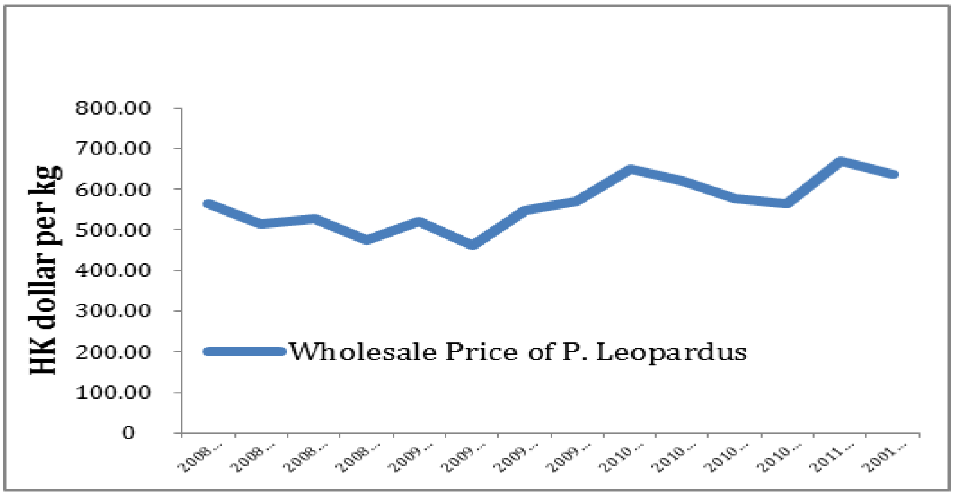
Traders or Buying Station. Traders maintain aquaria in their houses, which are rented by the exporter on a monthly basis. Their main role in the supply chain is to assemble fish in quantities suitable for transport and to prepare the fish for transport (either by air or by ship). After delivery by the cager/fisher, fish are acclimatized and moved into aquaria 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 then into cardboard boxes completes the preparation. It is a very sensitive task requiring high levels of skills and precision, which has been described in great detail by Chan (2000).

Traders or buyers in Taytay and Quezon are agents of the exporter based in Manila, who also has an established trade link with an importer based in Hong Kong. An experienced operator knows how much time the packing team requires to pack one box, so the team will start packing with just enough time for them to finish their task and move the container to the airport in time for the flight. Traders are said to derive commissions, but they have denied this and say that their earnings come from “rentals” of aquaria. For purposes of value chain analysis, the traders’ earnings are charged against the exporters as costs because they do not earn from a price differential but from mere rentals.

Exporters. The contribution of exporters to the supply/value chain is in terms of capital, operating expenses, and own labor. A large amount of investment is needed to purchase the fish from the fishers/cagers while operational expenses are incurred for transport, holding, marketing, and documentation. Once the fish reach Manila, they are revived and repacked. Information collected for 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 (Sea Dragon, Great Ocean, Kenneth Aquamarine, and Fordelon). The informants for this study also mentioned YMP and GB Company as their main contacts. Consistent with the observations of Padilla *et al*. (2003), the exporters have tie-ups with local buyers/trading stations or the latter act as their agents. Exporters secure export commodity clearance, export declaration, and export permit in addition to paying insurance fees (security service charge and airway bill).

Pricing Characteristics. From October 2008–May 2011, wholesale prices of *P. leopardus* were above HK$500 per kg (**Fig. 35**). From 15-21 July 2011, it was HK$561 per kg; retailers sold at HK$498–906 per kg (US$64–116 per kg). Peak pricing is noted during celebrations, such as Chinese New Year, Christmas, and Mother’s Day, as well as 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).

Figure 35: Wholesale Price of *P. leopardus*, 2008–2011



Source: Fish Marketing Organization, Hong Kong.

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

Three price levels were analyzed to determine price differentials: (i) retail (HKG); (ii) wholesale (HKG); and (iii) fisher/cager, which can be said to be the beach price. From the information generated through structured interviews and FGDs, prices at the fisher/cager level are wide-ranging (**Table 39**). In Quezon, prices start at Php1,800/kg for a good-size grouper, but in Taytay, the starting price is Php2,000/kg. Data collected by WWF indicate that prices for red grouper can go as high as Php2,800/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 mentioned case, increasing the volume would make the cost of transport cheaper, thereby increasing margins.

Table 39: Pricing of LRF across the Supply/Value Chain

Selected Value Chain Participants	Price Type	Price Range (per kg, unless stated otherwise)
Fisher/Cager	Good size	PhP1,800 -3,000
	Tropical	PhP 0.50-0.75 per pc
	Over-sized	PhP 300
	Other species (brown grouper)	PhP 1,600
Wholesaler	Wholesale price (Hongkong)[62]	HK$300–775; US$ 39–100; PhP1,656–4,278
Retailer	Retail price at Hongkong restaurants[52]	HK$498–907; US$64–117; PhP2,750–5,000

Note: Exchange rates used are US$1=PhP44 and HK$7.8.

Using PhP1,800 as the base price, the differential between the price received by the fisher/cager and the wholesaler based in Hong Kong is almost 100%, while there is an observed overlap between the price range of the wholesaler and the 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/cager and wholesaler and 30% between the wholesaler and retailer. The mark-up observed in this study is less than that observed by Sadovy et al. (2003), who pointed out a 100%–150% mark-up between wholesale to retail, but is consistent with the observation of Chan (2000) in that the mark-up between wholesale and retail is between 24%–35%.

At the fisher/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 five times more than an undersized or oversized fish. This pricing basis contributes to the growth overfishing currently being experienced in Palawan because of the preference for smaller 'tropical' fish that can be caged and grown to marketable size in three to four months.

Table 40: Comparison of Grouper Prices based on Size, Average, and Peak Prices in Palawan, Philippines, 2009

Size Category	Average Price (PhP/kg)	Peak Price (PhP/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

Source: Cantos *et al*., n.d.

5. Value Retention at the Fisher/Cager Level

To complete the analysis of value retention, the study analyzed costs/revenues of fishing and caging (**Table 41**). 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 and Quezon at 0.30 kg and 0.33 kg per fisher hour, respectively; (ii) level of effort in Taytay is four hours per day, 20 trips per month, and 12 months per year, while that in Quezon is

[62] As of January 2011.

120 hours per trip or five days, four trips per month, and 12 months per year; (iv) disaggregation of catch based on data in Section C.3 and Table 41; and (v) price differentiation.

Table 41: Estimates of Revenues from Handline Fishing in Taytay and Quezon, Palawan

Revenue Parameters	Taytay	Quezon	Price (PhP/kg unless stated otherwise)	Taytay Revenue (PhP)	Quezon Revenue (PhP)
Average catch per handline fisher (kg)	288	2376	-	-	-
Average catch of groupers (kg)	80.6	63.4	-	-	-
Average catch of other species (kg)	177.8	2269	100	17,784	22,6908
Average catch of invertebrates (kg)	29.5	42.8	100	2952	4276
Live groupers	78.4	38.8	-	-	-
Fresh groupers	2.2	24.6	300	668	7384
Good sized groupers	14.5	11	1800	26192	19447
Undersized groupers	47	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**

In the base situation, average annual revenue is around Php70,000 ($1,590) and Php267,000 ($6,136)[63] for each handline fisher in Taytay and Quezon, respectively. This translates into about Php6,000 per month for a handline fisher in Taytay and Php22,000 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 revenues in Quezon are contributed by catch other than groupers, while in Taytay, 38% of revenues come 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 and is based on the operating cost per trip (diesel, gasoline, food, ice, bait, hooks, and other catching implements). Repairs and depreciation were also estimated, with the latter based on investment costs. Investment costs for boats range from Php1,500–80,000; for the survey, the average value was Php14,500, which was used to compute the cost per trip. Using 240 trips per year and four crew per trip, the cost of one trip in Taytay is estimated at Php724, which is similar to the cost estimated by Padilla (2003) for Coron (Php672). In Quezon, the average investment cost is higher (Php73,000), although the boats are all less than 1 gt. Informants report that their boats are equipped with fishfinders and aquaria. At least two informants said that they have compressors. Operating cost is about Php7,500, ten times that of Taytay, since each trip in Quezon lasts for five days. The costs are for diesel, gasoline, kerosene, ice, food, coffee and juices, cigarettes, nylon rope, bait, *cristalet*, chicken feathers, and charcoal. Added to these is the depreciation cost of 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 (**Table 42**): 240 trips in Taytay (20 trips per month, 12 months per year) and 60 trips in Quezon (5 trips per month, 12 months per year). In the case of Taytay, pure handline fishing (without resorting to caging of juveniles) does not make good economic sense, as Php29,000 per year does not meet the poverty threshold requirements for a family of six. However, in Taytay, all fishers are cagers and vice versa. Thus, after caging juveniles, accounting for the feeds and a mortality of 30%, and imputing a price for the juveniles, the revenues from caging are greater than from fishing, mainly because of premium prices obtained for the fish).

Table 42: Estimates of Net Revenues (in PhP) from Handline Fishing, Taytay and Quezon

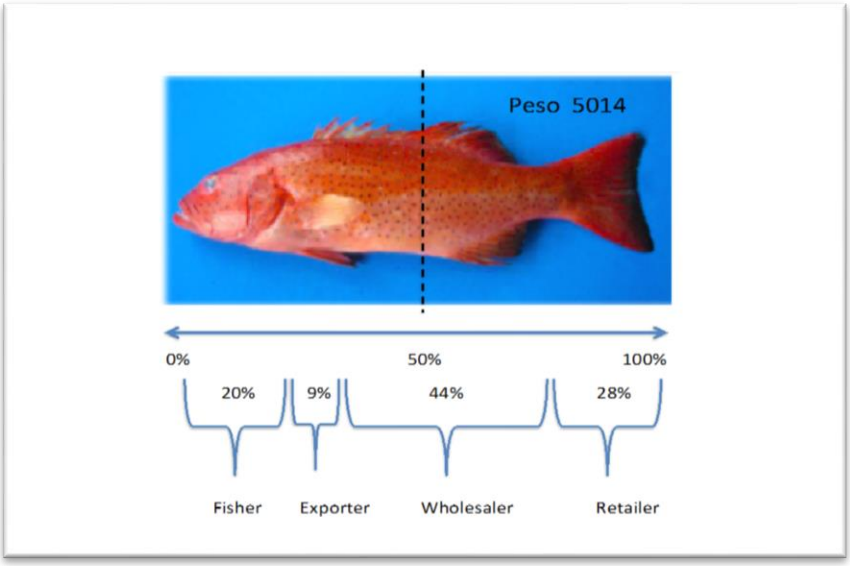
Parameter	Taytay	Quezon
Annual revenue, base situation	69,631	266,818
Cost per trip	672	8,700
Cost per kg	560	877
Cost per fisher/yr	40,320	174,000
Net revenue	29,311	92,818
Add: Revenues from caging	71,720	5,371
Total	**101,032**	**98,189**

63 Exchange rate used is $1 = PhP44.

6. Value Distribution for Entire Live Reef Fish Chain

The value chain distribution is depicted in **Figure 36**. The final value of PhP5,014 is the peso equivalent of the average retail price in Hong Kong and is distributed across the chain based on prices received.

Figure 36: Value Distribution along the LRF Chain



The wholesaler captures almost half of the value, while the fisher/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, estimates show that 30% are costs or the value-adding contribution (cost of feeds, cage, permits, and labor), while 70% are the margins. This is considering the fisher/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 of Taytay, the net revenues exceed that in Quezon because fisher/cagers are able to take advantage of the high prices of live grouper.

The literature suggests that wholesalers in Hong Kong are the price leaders, who influence downstream prices from supply countries by maintaining financial support to the shipper or importer. Pederson (2007) observed that in aggregate, retail and wholesale prices in Hong Kong and beach prices in source countries are integrated, or that 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 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 on the basis of 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 showed 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. With respect to the latter, margins earned by cagers can reach up to 70% of the total beach price and net earnings–consistent with previous studies on incomes of LRF cagers (Cola, n.d.; Padilla *et al*., 2003). At the Palawan annual per capita poverty threshold of Php14,308, a family of six would need about Php64,000 to meet basic needs and breach the poverty threshold. This threshold can be met by fishers/ 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 (Php50–Php75 per piece) or caging them and earning the premium price after a fattening period of three to four months.

There are three points to consider here. *First*, the catching of juveniles must be contextualized in the larger production possibility scenario, which includes catching good-size fish. As shown in **Figure 38**, as the ratio of good-size 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-size fish increases to 50%. *Second*, the caging of juveniles also needs to be costed appropriately. A cager/investor would only look at the feeds (cheap trash fish at Php30/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 of course, 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 individual 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 LRF for leopard coral grouper are inelastic with respect to own prices but elastic with respect to income levels.

The demand and pricing scenario for live reef fish is contingent on income levels in the importing country. In Hong Kong, both the severe acute respiratory syndrome (SARS) scare and the Asian economic crisis resulted in dipping demands and prices. Conversely, periods of stable income increase demand for fish, especially high-value species. Based on GDP data from Hong Kong, 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 two-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 live reef fish 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 result in depressing 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 MPA management. It is said that every 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 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 enable identification of users, exclude outsiders, and control sharing of accreditation. Stage 2 is relatively more difficult to enforce, especially among the voting populace, and limiting outsiders can only be successful if monitoring and enforcement exist. *Stage 3* is stricter enforcement of policy, while *Stage 4* utilizes economic instruments as incentives or disincentives for catching of juveniles. In particular, one recommendation is to price the use of waters for caging according to the number of months the fish are 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–pricing should relate to the correct valuation of ecosystem services and reflect the scarcity of resources.

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

1. Background

This section summarizes key findings of a study on coral trade in the Solomon Islands, including an analysis of value chains. The full report evaluates coral trade and its contribution to economic development, food security, and biodiversity conservation. It is part of a suite of reports prepared by the 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 Department of Sustainability, Environment, Water, Population and Communities.

Existing reports point to a modest (Albert, Schwarz, and Hawes, 2010) to significant contribution (Tietelbaum, 2007) to rural incomes in the Solomon Islands from the coral trade. The cash generated from the 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 their contribution as a rural engine of growth, i.e., income and distributional effects. It should be validated whether the impacts on rural economies are substantial; whether 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

The 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 for public and private aquariums of hobbyists as well as jewelry and other items (Lal and Kinch, 2005).

Prior to the Solomon Islands becoming a signatory to CITES (in 2007), the aquarium trade was first enabled by the *Fisheries Act* over which the Department of Fisheries and Marine Resources (DFMR) (now 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 being MECDM, while the scientific authority is the MFMR. In CITES rules, this means that the 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 the Solomon Islands appeared on the *IUCN Red List* and in the following year, 503 species of hard corals were likewise listed.

Currently, 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. Solomon Islands Marine Export (SIME), started by David Palmer, was the pioneer exporting company. He later left and established 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 SIME focusing on coral ornamentals and AASI focusing on aquarium fish. Currently, there is one exporter for the aquarium trade (Aquarium Arts) and two exporters for the curio trade (Halelo and Sea Abundance) (J. Albert, pers. comm., 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 aquaria 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 re-opened again in 2003 (Lal and Kinch, 2005). The curio trade involves the harvest of live corals (primarily *Acropora sp*.) from the reef – from small (< 25 centimeter [cm] diameter) to large coral pieces (>80 cm diameter), which, after harvest are placed on land in the sun to die and bleached white. The corals are then sent to exporters in Honiara prior to being shipped 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* (Tietelbaum, 2007). The same species of hard coral are exploited for the live and dead trade except that for the dead trade, larger sizes are required, sometimes entire colonies (Lovell, 2001).

From 1999–2010, averages of 74,000 and 102,000 pieces of corals were exported based on MFMR and CITES data, respectively. MFMR started recording both live and dead coral exports only in 2005 (**Fig. 37a**), while CITES monitored both live and dead corals during the entire period (**Fig. 37b**). Both MFMR and CITES data show an increasing percentage of dead corals in the total coral exports.

Figure 37a: Coral Exports from the Solomon Islands, 1999–2010 (MFMR data)

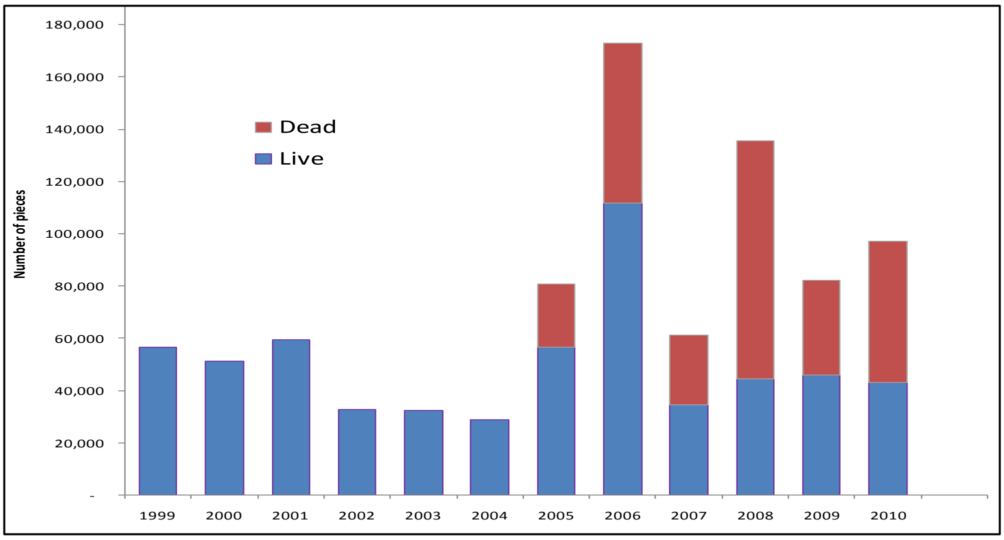
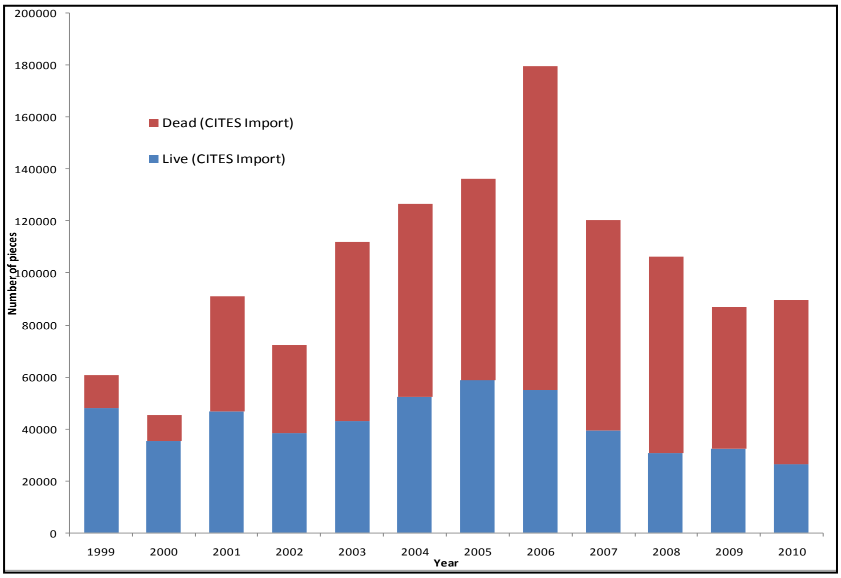


Figure 37b: Coral Exports from the Solomon Islands, 1999–2010 (CITES Data)



Over time, the coral market has grown in terms of trading partners (**Table 43**). There was a peak of nine trading partner countries in 2002. In 2005, France and Italy combined imported close to 12,000 pieces of corals. By the end of 2010, the number of import countries declined to five with the US and Japan remaining the largest importers. Notable was the entry of other Asian countries, including the Republic of Korea and Singapore in early 2000s.

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

Year	US	New Zealand	Germany	Hong Kong	Spain	UK	France	Denmark	Canada	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		

Coral farming was introduced to the 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, 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 in order 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/products and consolidation of products; and (iii) better pricing (Tietelbaum, 2007).

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, the exporter, the importer, the wholesaler, the retailer and the consumer. The last three participants are based in the importing country, while the collector/harvester and the exporter are based in the 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 importer/wholesale sector.

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 the 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 two or three people, usually from the same family or clan. The equipment includes knives, fins, chisels, baskets, and a canoe. No scuba equipment is used, which also limits the frequency of operations or duration of dives. Tietelbaum (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 the Solomon Islands can export at least twice as much as the current level of 70,000 pieces per year, which 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 the 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 SI$2.50 per piece, the exporter sells to the importer/wholesaler for SI$23.40, and the same size piece of coral is retailed at SI$234.[64]

Export prices of a selection of corals, based on data from Aquarium Arts, were compared with retail prices in the US based on 1999 data from Green and Shirley (1999) and current internet-generated data from www.bluestaraqua.com (**Table 44**). The species that are 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 FOB prices in the Solomon Islands vis-à-vis 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/supply chain analysis can assess whether costs and/or margins are excessive.

Table 44: Comparison of FOB Prices of Corals in the Solomon Islands with Average Retail Prices in the US, 1999

Species	FOB Prices ($/pc)	Average Retail Prices($/pc) Collected from Seven Retail Outlets in the USA, 1999[a]			Internet-listed Prices ($/pc) as of June 2012[b]
	Average or Range	Small (S)	Medium (M)	Large (L)	
Acropora spp.	4	40	53	73	43.99 (S)
Catalaphyllia spp.					
C. Jardinei	6–14	37	53	78	
Euphyllia spp.		22	28	33	
E. paradivisa	2.50–4.0				
E. ancora	4				
E. glabrescens	3				
Goniopora spp.	2.0–2.50	26	30	36	Branch *Goniopora*, 47.23 (S)
Heliofungia spp.	2.5	25	33	38	
Lobophyllia spp.	2.5–5.0	23	32	37	Colored teeth, 43.95 (M)
Nemenzophyllia spp.	2.5–4.0	27	32	38	
Plerogyra spp.	3.5–5.0	23	31	39	Bubble cat-eye, 43.99 (S)
Porites spp.	2–5	31	45	63	
Trachyphyllia spp.	2–5	26	38	41	Brain coral, 39.99 (S)

[a] Source: Green and Shirley, 1999
[b] Source: www.bluestaraqua.com

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/wholesaler for SI$33, and the same sized coral retails at SI$312. As the information on the selling price of the wholesaler to the retailer was not available, the price was estimated at SI$120, and does 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.

On average, each piece of coral is sold for $30 or about SI$210. Thus, the value that is retained in the Solomon Islands is the value derived by the collector, i.e., SI$2.50, and the export price, which can range from SI$8–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 (**Figs. 38 and 39**). The exporter earns 11%–16% of the total value, which is the basis for the Solomon Islands government 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/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) confirms the

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

huge disparity between value generation in the coral trade between exporting developing countries and retailers in the USA, with collectors/harvesters earning $5 million from the trade and retailers making at least $50 million in 1999.

Figure 38: Value Distribution for Live Coral Exports in the Solomon Islands

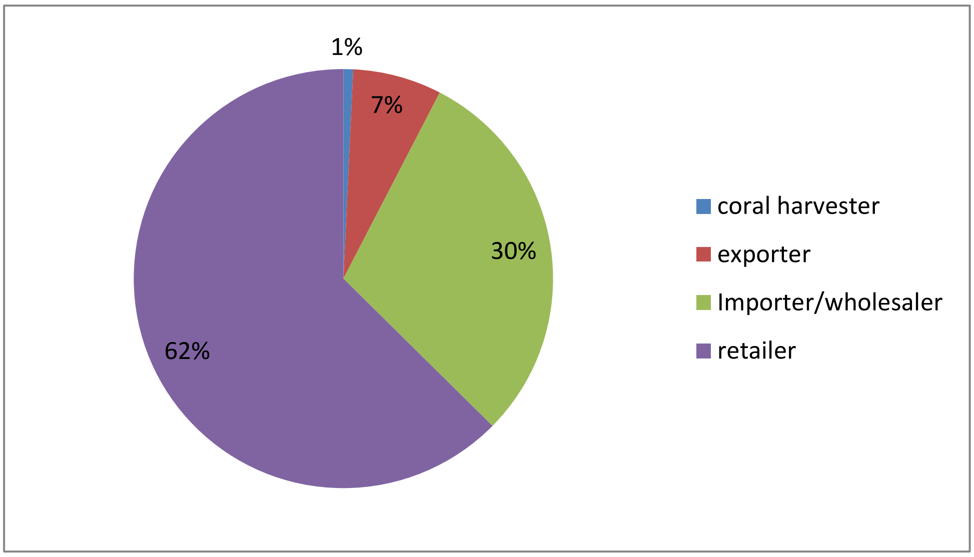
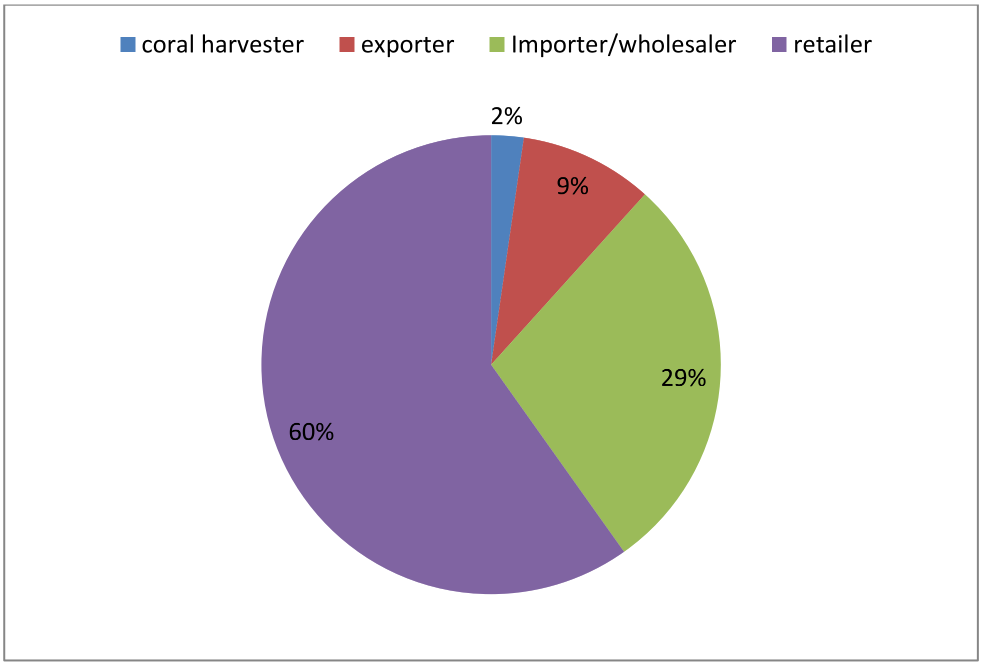


Figure 39: Value Distribution for Dead Coral Export in the Solomon Islands



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 UNDP Household Incomes and Expenditure Survey for the Solomon Islands (UNDP Pacific Centre, 2005/2006). Summary statistics for daily per capita expenditure on food and nonfood items are shown in **Table 45**.

Table 45: Per Capita Average Daily Expenditure for Food and Non-food and Percentage of Non-food Household Expenditures Covered by Coral Collection at Three Collection Levels

Item	Daily Expenditure Requirements (SI$)		Household Size (Number of Persons)	Various Collection Level Scenarios and Percentage of Non-food Expenditures Covered		
	Food	Non-food		5 pcs/day	10 pcs/day	15 pcs/day
National Average	32.59	14.66	6.2	0.69	1.37	2.06
Rural	27.48	12.09	6	0.86	1.72	2.58
Total coral collection required (pcs/yr)				60,000	120,000	180,000

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

5. Conclusion

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

Of the total value of coral exports, less than 5% is retained at the fisher/harvester level and another 10% with the exporter. The lower price paid to the 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 non-food requirements may be covered from this source. Despite the modest amounts, the shift to a cash economy highlights the desire to generate cash income. In order to add value to the Solomon Islands' coral trade, an option is to market sustainably farmed corals, which would require a premium price and government export subsidies.

Learning about the nuances of the coral trade can inform policies that should guide government with regard to the coral trade. There are potential earnings that can be derived from the trade, which can contribute to national income as well as to livelihoods and cash income for communities. Moreover, decisions concerning the 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 benefits derived from coastal protection.

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CHAPTER VII
ASSURING SUSTAINABLE FISHERIES DEVELOPMENT THROUGH ECOSYSTEM RESILIENCY AND FOOD SECURITY

A. The Importance of Fisheries in the CT

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). More recently, the quality and safety aspects of food have also been regarded as important components of food security. In the CT, 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 CT as a supplier of fish to the world, food security in the region remains a challenge. Food security issues have been depicted by Foale *et al.* (2013) and Cabral *et al.* (2013) as being further exacerbated by a myriad of anthropogenic and climatic threats. A recent evaluation of the national vulnerability of fisheries, reef management, and food security to climate change in 27 countries included the three CT-SEA countries—Indonesia, Malaysia, and the Philippines. Among these three countries, Indonesia was ranked as the most vulnerable to climate change, while the Philippines ranked fifth and Malaysia was the least vulnerable (Hughes *et al.*, 2012). The CT6 also have high socioeconomic vulnerability, considering that 16.6% of the total population are poor, and around 13% are undernourished (**Table 46**).

Table 46: Poverty and Undernourishment in the CT6

Country	2011 Human Population[a]	Percentage of Population below National Poverty Level [b]	Proportion of Undernourished in the Population (%) (2005–2007)	Number of Undernourished in the Population (estimate for 2011)
Indonesia	241,600,000	32,132,800 13.3% (2010)	13	31,408,000
Malaysia	28,990,000	1,101,620 3.8% (2009)	2	579,800
Papua New Guinea	7,000,000	2,590,000 37% (2002)	26 (1995–1997) (see note)	1,820,000
Philippines	94,200,000	24,963,000 26.5% (2009)	15	14,130,000
Solomon Islands	540,000	122,580 22.7%[c] (2006)	11	59,400
Timor-Leste	1,092,000	544,908 49.9% (2007)	31	338,520
Total	373,422,000	61,454,908 16.46%		48,335,720 (12.94%)

[a] Asian Development Bank. *Key indicators for Asia and the Pacific 2011*. www.adb.org/statistics;
[b] MGD Statistics Division
[c] Solomon Islands National Statistics Office and UNDP Pacific Centre, Suva, 2008.
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.

Poverty incidence in the coastal fishing communities of the CT6 is generally higher than the national average. For example, 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 (Ministry of Agriculture and Fisheries, 2012). In many of the Pacific countries, importation of food is increasing because of the declining per capita production of food caused by rural-urban migration and changing food preferences (Sharma, 2006). Malaysia, though currently food secure, is heavily reliant on imports of fish to support the consumption and needs of its population, which makes them susceptible to fluctuations in the supply of fish from other countries.

There are many sources of vulnerabilities in coastal fishing communities. These communities are usually excluded or not given much attention in social, human, and economic development programs. Often, stakeholders are disadvantaged in terms of economic transactions, making them vulnerable to marginalization. This highlights the importance, discussed below, of having a level playing field 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 the previous chapter, much of the value adding contribution of trade is retained by the wholesaler or retailer. For example, in coral trading in the Solomon Islands, a mere 1%–2% of the value of exported corals is retained by coral harvesters.

Signs of deficit in fish supply in the CT6 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 the Solomon Islands and in PNG is currently below the standard requirement to satisfy their present and future dietary protein needs (Bell *et al.,* 2009).

Fish provide more than 30% of animal protein consumed by people in the region. In Indonesia and the Solomon Islands, it is more than 50% (**Table 47**). In the CT, with a population of 373 million, 16% of whom live below the poverty line, average fish consumption is about 20 kg per capita per year and higher in coastal communities. In Malaysia, fish consumption is 60 kg per capita per year (**Table 47**).

Table 47: Socioeconomic Fisheries Statistics of the CT6

	Malaysia	Indonesia	PNG	Philippines	Timor-Leste	Solomon Islands	Asia	Oceania	World
Fish Supply (2007)(t)[a]	1,489,953	5,460,553	103,692	3,138,560	4024[c] (2004 data)	16,734	75,207,046	868,210	114,026,910
Per capita fish supply (kg/ person/yr) (2007)[a]	56.1	24.3	16.1	35.4	4.4[c]	33.6	18.7	25.2	17.1
Fish protein (gram/capita/day) (2007)[a]	17.1	8.0	5.2	11.3		11.6	5.1	6.5	4.8
Animal proteins (g/capita/day) (2007)[a]	39.0	15.3	40.2	25.3		15.3	23.1	61.9	29.6
Total protein (g/capita/day) (2007)[a]	77.9	56.7	75.5	60.0		52.1	72.5	97.8	77.3
Fish/animal proteins (%) (2007)[b]	43.8	52.5	12.9	44.7		75.7	22.3	10.4	16.1
Fish protein as a % of total protein supply (2007)[b]	21.9	14.1	6.9	18.9	see note	22.2	7.1	6.6	6.2
Fish consumption (kg/person/year) [b] (Average 1990-1992)	48.18	15.33		35.41		45.63			

	Malaysia	Indonesia	PNG	Philippines	Timor-Leste	Solomon Islands	Asia	Oceania	World
Fish consumption (kg/person/yr)[b] (average, 1995-1997)	55.85	18.98		29.93		41.25			
Fish consumption (kg/person/yr)[b] (average, 2000-2002)	60.23	21.54		29.20		31.03			
Fish consumption (kg/person/year) [b] (Average 2005-2007)	51.10	23.36	13[d]	32.49	see note	31.03			

[a] FAO (2010). [b] FAO (2012b). [c] FAO (2012a), [d] Bell et al. (2009).
Note: FAO fish protein statistics for Timor-Leste were not presented since they do not coincide with some country reports.
Source: Data from Cabral *et al.* (2013, supplementary file).

Small-scale fishing, which accounts for the bulk of employment in the sector in the CT, 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 CT. 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, assuming an average household size of five, 75 million people in the region are directly dependent on fisheries for food, income, and livelihood. Additionally, 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, boat-building, 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 five decades, threatening fishers' incomes, fisheries 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 both 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 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 methods, and resource-use conflicts. Although new opportunities are emerging, the sector should learn lessons from past mistakes.

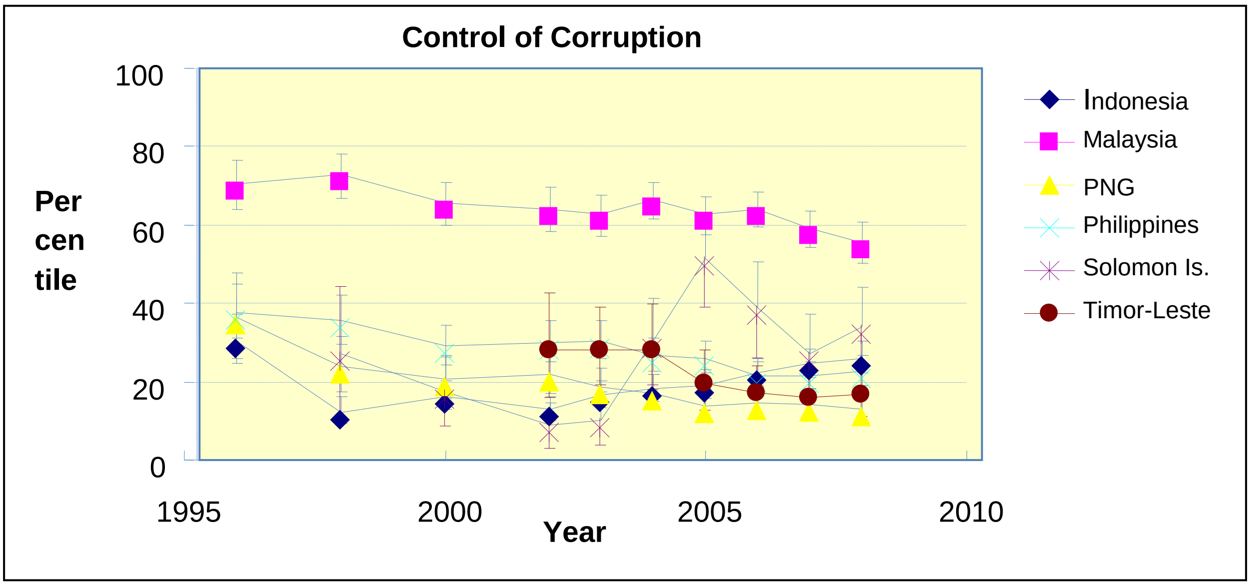
B. Key Drivers Affecting Fisheries Ecosystem Sustainability

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

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 fisheries, 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 *et al*., 2009), all the CT6 countries, except Malaysia, fall below the 40th percentile of the assessed countries (**Fig. 41**).

Figure 41: Control of Corruption in the CT6, 1995–2008



Source: Kaufmann *et al*., 2009.

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, as well as other stakeholders, in helping the laws and regulations work. To date, the involvement of local communities is improving in the CT6 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 CT, are poorly enforced, if not unenforced. In the CT6, 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.

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 weakened. 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 fisheries, 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/policy making in fisheries is the lack of reliable data and information about various facets of the sector. Currently available statistics are often highly inaccurate and minimally useful and seldom sex-disaggregated or gender-related.

Socioeconomic Conditions. A number of socioeconomic factors constrain improved fisheries management and are the root causes of some overfishing problems in the region.

Poverty. In many areas in the CT6, 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, and behavior towards 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 has 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 *et al.*, 2003), which is the case in the CT6 (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 human 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[65] 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 t/ km^2 (ADB, 2003). Current estimates of average grouper yield reach 2 t/km^2 (Muldoon *et al.*, 2009). The individual studies in Taytay and Quezon municipalities in Palawan province, which provide over half of the supply of live reef fish in the Philippines, indicate growth overfishing, as

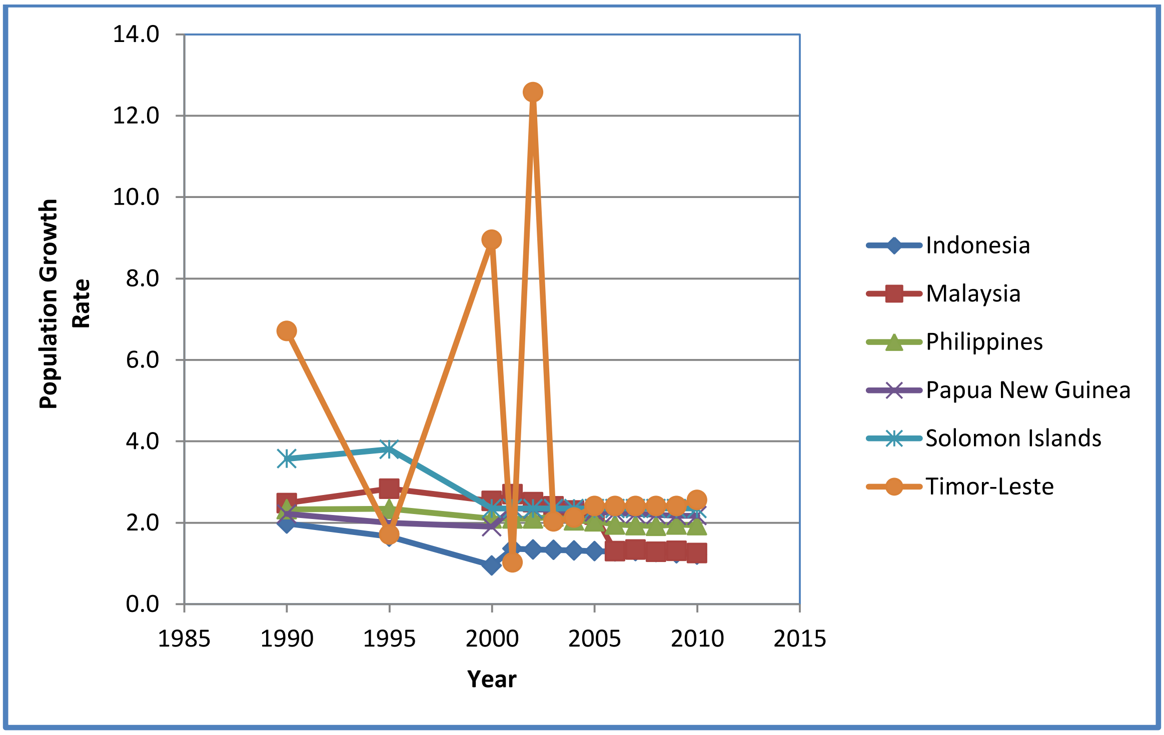
[65] defined as fishing beyond the level at which fish stocks can replenish themselves through natural reproduction.

shown by the targeting of small individuals for fattening in cages before they are sold in the live fish trade.

On 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 due to 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 coming years, while coastal ecosystem functions and services continue to diminish (Burke *et al*., 2012). Human population growth rates in the CT6 have been stable in the last five years (**Fig. 42**). Given the combined population of the CT6 in 2011 of around 370 million (**Table 46**) and considering a constant rate of population increase, the combined population of the CT6 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.

Figure 42: Population Growth Rates in the Coral Triangle Countries, 1990–2010



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 have been left behind as economic development has progressed in other parts of the country, 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 related to fisheries include gender division of labor and income, gendered access to decision making (representation and advocacy), gender-based rights to natural and other resources, and gender-based access to markets, market information, trade, and livelihood.

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 CT. However, there are also indirect human activities that affect the biodiversity and productivity of fisheries ecosystems. These include pollution from land-based sources, as well as 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 and 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) suggest that almost all of the coral reefs of the CT will be extremely threatened by coupled anthropogenic and climatic stressors.

Coastal and Aquaculture Development. The rapid transformation of the coastal areas is mainly due to the fast pace of coastal development in the 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-farming families, and increased inflow of nutrients from household waste 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).

IUU Fishing. Illegal, unreported, and unregulated fishing is a major source of economic leakage occurring both in the high seas and coastal waters and is, thus, considered as a confluence of several drivers discussed earlier: 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 1.26 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.

Box 1. Summary of a study of Illegal, Unreported and Unregulated (IUU) Fishing in the Arafura Sea, Indonesia
Gabriel A. Wagey

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

Fish catch which is not reported (unrecorded) is one of the components of IUU (illegal, unreported, and unregulated) 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 long lines.

Based on data records, 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 including estimation of uncertainty using Monte Carlo simulations. Unrecorded catch is divided into catch which is thrown away (bycatch, discards), catch which is not reported, catch which is reported but not recorded or improperly recorded (misreported), and illegal fishing activities. In the early stages of shrimp exploitation, bycatch was relatively high but recently there has been an increasingly downward trend in bycatch in this fishery for about 50%.

Bycatch from the capture of finfish using fishnet and bottom long lines can be considered negligible as hardly any fish are discarded. The highest level of misreported catch (95%) occurs in the bottom long line fishery, followed by the fish net fishery and is least in the shrimp trawl fishery. The highest level of illegal catch (average 35%) occurs in the fish net fishery, where fish are directly transferred (trans-shipped) 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 long line fisheries are unknown, but are assumed to be around 5%.

Assuming that the price of fish is US$1 per kilogram, the activities of Illegal Fishing in the Arafura Sea caused financial losses of 5.9 trillion/year. This figure does not include losses due to by-catch that are discarded (unregulated) and the catches that were not reported (unreported). The by-catch that are discarded were estimated around Rp.2.2 trillion/ year, while the unreported catches amounted Rp.3.3 trillion/year. The annual average of illegal catches was estimated at 654.6 thousand tons, then 239.7 thousand tons were discarded and those were not reported were estimated at 364 thousand tons. The annual average of total loss of Indonesia due to the IUU fishing in the Arafura Sea reaching 1.26 million tonnes.

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 11–26 million t, accounting for about 10–22% of the world's total fisheries production and valued at about $10–$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-Pacific region, the total estimate of production from IUU fishing could be around $5.8 billion annually (**Table 48**).

Table 48: Selected IUU information in the CT*

Site/Country	Year	Species in IUU	IUU	Value ($)
Raja Ampat, Indonesia[a]	2006	Reef fishery	20 of 26% 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 million/yr
Philippines[b]		All	80,000 t (by foreign vessel fishing)	1.6 million/yr
PNG[e]		See "IUU" column	6,000 t tuna, 400 t shrimps, 6,000 t sharks, 2,000 t sea cucumber and 11,000 t demersal/coastal fishes	26.55 million
Indonesia[f]	2001		85% of all vessels >50 gt (~7,000 vessels) operated without license	
Arafura Sea, Indonesia[f]	1980s-1990s	All	Thai-based operators reportedly responsible for biggest loss of earnings (60%)	
Indonesia[f]	2002-2003			~2.1 billion/yr
Indonesia[f]	2006			~3 B
WCPO[g]		Tuna		134-400 million
Sulawesi Sea[g]				227 million
Indonesia/ Philippines[g]				2 billion
PNG[g]				26.5 million
Indonesia[h]	2003			103.3 million
Indonesia[h]		Large pelagics	Purse seine and longline	153,604
Indonesia[h]			Cyanide	46 million
Philippines[h]			80,000 t	1.6 million/yr

* Prepared by Richard Muallil
Data sources: [a] Varkey *et al.*, 2010; [b] Palma and Tsamenyi, 2008; [c] www.illegal-fishing.info[1]; [d] www.illegal-fishing.info[2]; [e] MRAG 2005; [f] Budy *et al*., 2009; [g] Lack, unpublished; [h] Budy *et al*., 2009

Literature collected show 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 beche-de-mer, and 11,000 t of demersal/coastal fishes were estimated to reach $27 million. In the Philippines, the estimate is 80,000 t or $1.6 million per year from foreign fishing vessels alone (Palma and Tsamenyi, 2008).

C. Management Approaches toward Assuring Fisheries Ecosystem Sustainability

This section discusses key approaches and actions to address the priority issues and threats facing fisheries in the Coral Triangle region — weak governance, excess fishing capacity, illegal fishing, poverty, and livelihoods. We first review existing fisheries management tools and strategies implemented by the CT6 based on inputs from fisheries researchers and scientists and a workshop conducted with the ADB RETA 7307 Knowledge Integrators for the CT6.

Given the diversity of fisheries in the Coral Triangle, a myriad of tools and strategies are being implemented by the CT6 to help manage the fisheries and sustain fish production. Most of these management strategies focus on regulating fishing effort and catches to help ensure sustained fish production. The UN 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 CT

Fisheries management in the Coral Triangle employ both input and output controls as well as some conservation measures, which can be classified under EAFM.[66] Input controls are more commonly employed in the CT6 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 in the CT6 but at varying degrees of enforcement. Timor Leste recently established its first MPA. In all CT6 countries, destructive fishing gears, such as use of dynamite and cyanide, and the use of air compressors to assist fishing have been prohibited on a national scale.

Table 49: Fisheries Management Tools and Strategies Implemented by the CT6

Management Tools	Indonesia	Malaysia	Philippines	Solomon Islands	PNG	Timor-Leste
1. 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 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	✓	✓	✓	✓	✓	
2. Output controls (catch)						
Catch quotas or total allowable catch				✓	✓	
Fish size limits			Local/species	✓	✓	
Limiting by-catch and discards	Turtle		Tuna/turtle / dolphins	Tuna/turtle	Tuna / turtle	
3. Conservation measures						
Seasonal closures / fishing bans related to reproduction of fishes or migration runs	✓	✓	✓	✓	✓	
Fish habitat restoration	✓	✓	✓	✓	✓	
Stock enhancement and restocking	✓	✓	✓	✓	✓	
Ban on species (e.g., napoleon wrasse; turtles)	✓	✓	✓	✓	✓	
4. Subsidies Financial subsidies provided by governments (e.g., free gears or boats, discounted gas prices, tax cuts, etc.)	✓	✓	✓			
Gear buy-back		✓	Few (pilot)			
5. Traditional fisheries management (e.g., sacred areas)	✓	✓	✓	✓	✓	

[66] To obtain the information on management tools and strategies, a form was disseminated to fisheries officials and staff, fisheries managers, researchers, and experts in the CT6 with the request that they identify existing fisheries management tools and strategies implemented in their respective countries in the CT region.

Conservation measures are also being implemented by the CT6. These include seasonal closures in observance of important fish life cycle stages, fish habitat restoration strategies, restocking of fishery resources, and banning of catching of some species of fish and invertebrates. Compared to input controls, however, these measures are employed more locally and vary greatly in detail across the CT6.

Subsidies are implemented primarily by the Southeast Asian countries of the CT6. Respondents from the Pacific countries did not note the provision of subsidies in their responses although the move of Solomon Islands, PNG, 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 the Pacific than in the CT-SEA. Sacred areas serve as *de facto* protected areas for fishing, which is embedded well within the culture of local communities. The CT-SEA could learn from their Pacific counterparts in these types of management interventions.

Lastly, output controls are least employed by the CT6. The multi-species, multi-gear fisheries, as well as the presence of significant numbers of small-scale and subsistence fishers, make the implementation of catch quotas very difficult in the CT6. In some countries, employing fish size restrictions are 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 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 CT 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 non-resource-related issues of poverty, vulnerability, and marginalization of coastal households and communities. The strategy needs to address multiple challenges including food security, employment, income generation, livelihoods, health, improved quality of life, social development and community services, and infrastructure.

This approach finds solutions in both 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 the vast array of seemingly unrelated policies that may have beneficial side effects for the fisheries sector. The broader policy context is justified by the understanding and development of linkages between fisheries resource 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 vulnerabilities among coastal fishing communities: (i) rights-based management; (ii) livelihood approach; (iii) social marketing; (iv) resource restoration; and (v) governance. The complementarity and synergistic impacts of these strategies, when integrated and considered holistically, are discussed toward the end of this section.

2. Rights-based Resource Management

Many fisheries in the CT6 are being managed sustainably using traditional management systems. Such management systems 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 stock, 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 of the CT6 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 LGU has sole responsibility for maintaining the sustainability of their 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, Philippines). In Malaysia, fishing grounds are compartmentalized, and fishers are assigned to fish only in specific fishing grounds. In the Pacific 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.

Resource management must be innovative and utilize a mix of management measures. Difficult decisions will need to be made about 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 rights and territorial use rights for fishing (TURFs) 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, resource 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, there will be a need for effective monitoring, control, and surveillance (MCS) measures.

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 entitlements, i.e., who is entitled to have access to the fishery? This question will need to be addressed initially and is best accomplished through participation from, 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 a variety of 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, who has based his family's livelihood strategy on having access to fish for drying for food during lean periods, will affect the food security of the farmer's family. 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, 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. The Livelihood Approach to Fisheries Management

The livelihood approach focuses on what the community has, rather than on experimenting on other interventions, which 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 fishers' needs, his/her dependents, and the broader community in which he/she belongs. 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 to the 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 employment 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, analyses of trends and projections in both the regional and national economies and in future occupational demands can provide directions for skills training and microenterprise development. Economic base 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 the exit from the fishery and reduce the household's economic dependence on the fishery (Muallil *et al*., 2011). Families tend to have a certain household income need. If a household livelihood strategy is taken, rather than just focusing on the fisher, it is possible to provide this broader 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, for example, the establishment of management measures that will reduce overall effort or restrict access to the fishery with more limited 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 the use of information technology.

In addition to livelihoods, there is a need to improve the basic public services provided to coastal households and communities. Social and community development efforts can help ensure the expansion of opportunities in communities by integrating population, health, education, welfare, and infrastructure (e.g., roads, communication, water) programs into the approach, thus reducing 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 to 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 any policies that reduce the number of fishers in small-scale fisheries without creating non-fishery employment opportunities will inevitably fail. This is because 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 LRF 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 play a significant role in maintaining the integrity and ecosystem services of the resources in the coming years. Social marketing involves the promotion of the roles of people in the maintenance and improvement of the ecosystems in the 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 judgments 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 CT 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 is important in providing transformational opportunities for empowering the fisher stakeholders and providing enabling mechanisms through innovative ordinances (e.g., conditional cash transfer [CCT] 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 *et al*., 2008) and other premiums for environmental management.

Instead of the business motivation of eco-businesses in coastal resources (e.g., payment of environmental services), the context of social and economic impediments is considered important in the formulation of barrier removal mechanisms. There is a necessity to identify barriers in the governance measures to allow for a more enabling condition toward fair and environmental-oriented actions (Fabinyi, 2012). How can positive social change foster positive individual behavioral change within a community and overall societal benefits? For example, setting up incentives to encourage fishers to become stewards of marine sanctuaries is being initiated (EcoGov Project, 2011). Poor fishers can be targeted as priority beneficiaries for CCT programs. Capacity building opportunities should also be a complementary mode of 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 the people involved on the production side. They should also take into consideration the societal imperatives of fairness, allocation of benefits, and costs as guiding principles within their cultural values as integrated in the sustainable development perspective. While a primary social enterprise objective seeks 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 where eco-enterprises involve targeting the vulnerable fishers (e.g., to climate change and other stressors, such as coastal development, that may result in marginalization of fishing communities) (Allison, 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

MPAs can protect target species from exploitation and allow their populations to recover through closing an area or a population/s 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 non-consumptive uses of the resource. In addition to closing areas through MPAs, there is a need for restoration of 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 co-management, 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 co-management can provide a framework for such a coordinated and integrated approach. Empowered and organized people are more able to plan and engage in the often complex discussions and planning needed to realize this approach. Community-based co-management can serve as a mechanism not only for resource 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 action.

In general, there is a growing recognition of the critical role of local governments in achieving the goals and targets of the CTI-CFF. This is consistent with the guiding principles espoused in the RPOA stating that “*CTI-CFF should be inclusive and engage multiple stakeholders including local governments,*” among others. CTI-CFF began recognizing the value of local government participation at the seventh Senior Officials Meeting (SOM7) held in October 2011). The value of the CTI-CFF was also acknowledged at the Mayors’ Round Table conducted in Wakatobi, Indonesia and at SOM8 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 CT as well as those communities most dependent on—and therefore 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 towards decentralization. This refers to the systematic and rational dispersal of power, authority, and responsibility from the central government to lower or local-level institutions to states or provinces in the case of federal countries, for example, and then further down to regional and local governments, or even to community associations. While decentralization was addressing general government administrative restructuring, it was also undertaken in support of government policies and programs, which stressed the need for greater resource user participation and the development of local organizations to handle some aspects of fisheries management (**Table 50**).

Table 50: Role of Local Government in Fisheries Management across the CT6

Country/ Local Government	Role of Local Government in Fisheries Management	Controlling Policy
Indonesia 33 provinces, 1 special capital region, 399 districts or regencies, and 98 cities or municipalities	Municipal/district and provincial level governments have management authority over as much as 4 and 12 nautical miles (nm), 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; (e) participation in the maintenance of security; and (f) participation in defending the state	*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), 3 federal territories	None	Fisheries Act of 1985 (as amended in 1993)
Papua New Guinea 20 provinces, 89 districts, 286 rural LLGs, and 26 urban LLGs	Pass and enforce ordinances for management of fishing and fisheries and local environment provided 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	*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 km from the farthest offshore island).[d]	*Philippine Fisheries Code* (1998); *Local Government Code* (1991)
Solomon Islands 9 provinces and 1 capital city	For the provincial assembly to legislate on matters such as cultural and environment matters; agriculture and fishing particularly with respect to protection, improvement and maintenance of fresh-water and reef fisheries; control and use of river waters, pollution of water, provision of water supplies; land and land uses like codification and amendment of existing customary law about land, registration of customary rights in respect of 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)[h] (2009, amendment) *Provincial Government Act of 1977*
Timor-Leste 13 districts, 67 subdistricts	None	*Fisheries Decree* (2004)

[a] *Act 32/2004, Decentralization Law of Indonesia.*
[b] Sec 42 &44, No. 29/1998, *Organic Law on Provincial Governments and Local Level Governments of PNG.*
[c] No. 29/1998, *Organic Law on Provincial Governments and Local Level Governments of PNG.*
[d] Sec 16, *Republic Act 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 three nautical miles (nm) extending seaward from the low water line of each island in the province. In the instance where 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 three nautical miles from the low-water line of the atoll or reef.
[g] *Act No. 6/1998, Fisheries Act of Solomon Islands.*
[h] *Act No. 6/1998, The Fisheries Act of Solomon Islands.*
Source: Philippines' Department of Interior and Local Governments (DILG) (2012); others are from UCLG Final Report (2011).

For example, the Philippine *Local Government Code of 1991* calls for the decentralization of government functions and operations to LGUs 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) level for the exploration, exploitation, conservation, and management of marine resources within four nautical miles of the province's jurisdiction.

The countries of the CT 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 resource 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, the Philippines, PNG, and the Solomon Islands, laws support community-based management. In PNG and the 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 the 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 Sabah state government have stressed the need for more community involvement in fisheries management and establishment of community-based co-management initiatives while still favoring strong central control of fisheries management.

The important role of local government to support coastal and fisheries resource management and people's participation in management can only increase in the future. Local government can provide a variety of technical and financial services as well as assistance to support local resource management arrangements, such as with the police for enforcement, conflict management, appeal mechanism, and the approval of local ordinances for resource management. There are many lessons on coastal and fisheries resource management by local government that can be learned and shared among the CT6. 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

DEFINITION OF EBM, EAFM, EBFM, AND ICM

Ecosystem-based management (EBM): 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. EBM emphasizes the protection of ecosystem structure, functioning and key processes; is place-based in focusing on a specific ecosystem and the range of activities affecting it; explicitly accounts for the interconnectedness among systems, such as between 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 (EAFM): An ecosystem approach to fisheries management and development 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-based fisheries management (EBFM): Considered to be a component of ecosystem-based management, focused on a single sector. EBFM 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 (ICM): 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. *Coral Triangle Regional Ecosystem Approach to Fisheries Management (EAFM) Guidelines*

FAO (2003) defines the ecosystem approach to fisheries management as an approach 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*."

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 intersectoral governance. Its scale, scope, and the 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 and specific issues, or a single ecosystem function and service (White *et al.*, 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 considerations (Pomeroy *et al*., 2013). Geographical expansion can involve integrating management from town or *barangay*-based to baywide, municipal level, 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 multi-scale and multi-dimensional nature involves additional coordination, collaboration, integration, and synchronization of functions at various governance sectors and levels, in addition to a broader ecosystem consideration of fisheries management (Pomeroy *et al.*, 2013).

The effective application of EAFM is one of the five goals of the CTI (RPOA, 2009). EAFM is the preferred option for CTI towards achieving sustainable livelihood and food security (Pomeroy *et al.*, 2013). Four regional targets were specifically stated in the RPOA:

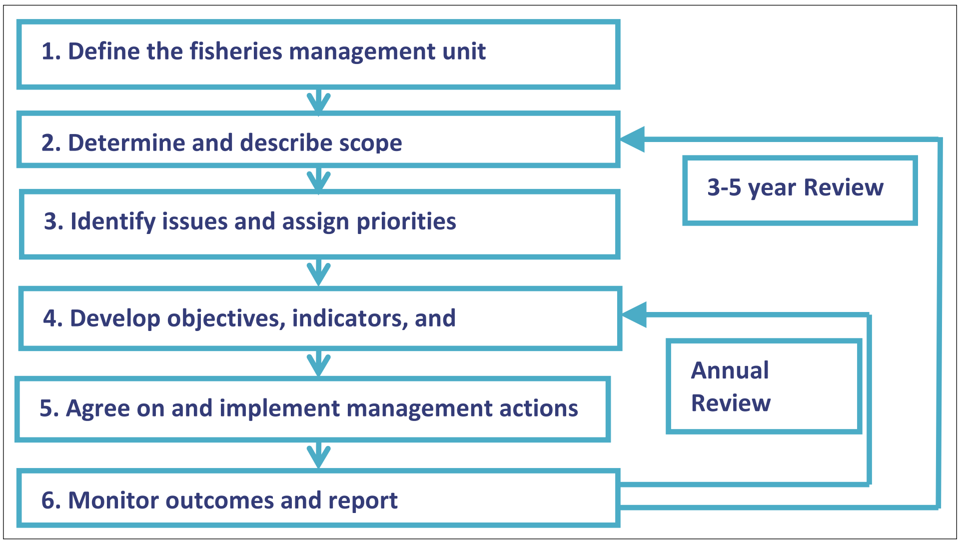
> *"Target 1: Strong legislative, policy, and regulatory frameworks in place for achieving EAFM;*
>
> *Target 2: Improved income, livelihoods, and food security of people in coastal communities across the region through a sustainable coastal fisheries and poverty reduction initiative ("Coastfish");*
>
> *Target 3: By 2020, effective measures in place to ensure exploitation of shared tuna stocks is sustainable, with tuna spawning areas and juvenile growth stages adequately protected; and*
>
> *Target 4: A more effective management and more sustainable trade in live-reef fish (LRF) and reef-based ornamentals achieved."*

Much 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, functional expansion in the form of a livelihood approach to fisheries management, which is compatible with social enterprise and territorial use rights/tenurial arrangements, will play a significant role. It is the view of the writers that enabling social and economic policies and laws are crucial to level the playing field and motivate the market (e.g., sustainability incentives through the value chain players) and non-market 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 the sustainability of the fisheries ecosystem.

For Target 3, tuna stock size, migratory patterns, and spawning grounds, as well as climate impacts on the stocks, remain as gaps (RPOA, 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 expansion, 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 (RPOA, 2009).

The need for developing an EAFM plan and its implementation, as well as M&E guidelines, has been articulated in the EAFM guidelines for the CTI (Pomeroy *et al*., 2013), which are consistent with the guidelines of FAO (2003, 2009) (**Fig. 43**) and SPC (2010). Climate-smart policies at the regional scale interlinked with various adaptive management measures at local and national scales can contribute to disaster risk reduction, e.g., local early adaptation plans (LEAPs) and regional early adaptation plans (REAPs) for straddling and shared stocks, which are necessary for regional strategic action plans.

Figure 43: FAO Fisheries Management Processes and Guidelines (2009)



The RPOA states, under EAFM, 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 the protection of at least 3,500 ha of critical habitats of economically important reef fishes. The progress of work towards this goal remains to be evaluated.

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 CT, 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 order to address these imperatives. Implementing EAFM requires putting in place the requisite governance processes, systems, and standards. This means addressing the impediments (e.g., no functional CT-EAFM bodies), barriers (e.g., CTI EAFM implementation agreements are in the incipient stage), and vulnerabilities that are presently high in most of the CT6 (Cabral *et al*., 2012).

Achieving the good governance objectives of EAFM in the CT requires accelerating capacity building efforts, 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), provisioning of goods and services (Padilla, 2009), and 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, aquaculture arrangements), and they 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’ (e.g., World Bank, 2004; Beddington *et al*., 2007; Cunningham *et al*., 2009 as cited in Allison *et al.*, 2012). This strategy is already being employed by the CT-SEA through contemporary tenure arrangements and has been an integral part of the culture and tradition in the Pacific 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 (RSCTR, in preparation). Capacity building in governance, social and economic resilience, and coping with perturbations is necessary in order 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*., 2004). Social marketing and social enterprises afford 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 *et al*., 2004).

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 the community network. 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 at the village or community level, e.g., if coral farming is accepted by the community and recognized by the government as a viable alternative to wild harvesting in the Solomon Islands.

A community, network, or fisheries association can establish support mechanisms to improve the quality of fish products and demand higher prices. In the 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. At the regional level, fair trade–rather than free trade–can be imposed if a regional policy body is present. Currently, the wholesaler controls the bottom (source) and top (retail) prices of the LRF trade. A regional management body can ensure that the supply is maintained at a sustainable level 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, and disconnects in governance, and ecological and socioeconomic conditions (Halpern *et al*., 2012; RSCTR, in preparation). It is imperative that the CTI make known within the governance structure and citizenry the compelling reason for the CTI basis of unity, viz., the highly connected resources in the center of global marine biodiversity. Both ecological and cultural affinities abound among the cultures of the CT6 that bind their past to their future development trajectories (Marsh, 2012).

EAFM within an overall archipelagic governance framework will play a significant role in resource management in the CT. The sustainability of ecological and social systems in the CT 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:

- Provision of good governance services through government agencies and service providers accountable to good performance standards and incentives through fair access and rights arrangements at local, national, and global arrangements;
- Demand for good governance through people’s participation, informed through science-based social marketing and responsible fisheries; and

- Community-based organizations engaged in sustainable fisheries enterprises and value-adding mechanisms both through market and non-market incentives.

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CHAPTER VIII
REGIONAL CALL TO ACTION

This concluding chapter provides a summary of the key findings of this study on the economics of fisheries and aquaculture in the CT and proposes a set of actions for implementation by the CT6 on a regional level to address issues that have been identified in the course of the study. 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 and consider other factors such as the linkage of the fisheries governance framework with the greater economic sector. That is why the eight regional actions recommended here range from the conduct of further research on marketing and coastal asset valuation to capacity building in economic literacy to policy harmonization at the regional level. These regional actions are mostly delimited by the existing 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 the CT6 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 t of the global production of tunas, bonitos, and billfishes came from the CT6 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 also produced 55% of the 7,753 t of global production of the ISCAAP species group of 'pearl, mother-of-pearl, and shell', and accounts for 80% and 90% of global harvests in corals and turtles, respectively.

Majority of fish stocks in Indonesia, Philippines, and Malaysia are considered to be at least fully exploited, and MSY 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 of fishing effort relative to the available fish stock, and leads to diminished private and societal profits and increase in illegal activities.

Aquaculture. Aquaculture production is increasing exponentially at a rate of 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 (i.e., 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 towards aquatic plants, rather than on foodfish.

The history of, and approach to, aquaculture in the CT-SEA and CT-Pacific CTI vary between these two subregions as a result of their different resource endowments, overall economic thrusts, and population pressures. Aquaculture in CT-SEA 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 is less significant than trade between them and the global markets, owing to similar resource endowments in the CT6. Demand for fish from the CT6 (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 resource 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 human well-being.

The 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 *UN Comtrade Statistics* indicate that coral exportation is still going on, with records being lumped with shells, pearls, mother of pearl, etc. Of the trading partners of the Solomons, none is more important than the USA, 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 the 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 at the household level in the Philippines amount to at least 16% of municipal fisheries production on a yearly basis, while the value of fish consumed at the household level is 22% of the daily food poverty threshold of Php162 ($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 the subsistence fisheries in the CT6 economies, it is necessary to make additional investments in data generation, preferably in collaboration with other non-fisheries agencies to provide more solid evidence for this contribution.

B. Recommendations

Based on the findings of this study, following are the proposed regional and national actions:

(i) Finalize and implement the EAFM policy framework that provides guidance on minimum common policies such as the following:

- Agree on common policies that curtail excess fishing effort and curb all forms of harmful fishing practices including coastal IUU fishing;
- Address economic leakages brought about by high seas IUU fishing through more efficient MCS systems, data sharing, and full compliance with the 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 RPOA in future iterations of the document

- Apply a harmonized standard for the harvesting, caging, and transporting of LRF consistent with the EAFM approach;

- Provide economic literacy training to aquaculture operators 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/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 the CT-Pacific countries

- Using 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 a variety of fisheries management tools ranging from input controls, output controls, conservation measures, traditional/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 in order to separate those listed under 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

- 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);
- Engage other agencies outside the fisheries/environment milieu to participate and co-fund data generation, which can be used for poverty mapping, investment planning, and climate adaptation–such agencies are those related to planning, statistics, social welfare and human development, health and nutrition, and local government oversight, etc.

(v) Conduct research, monitoring, response, and feedback systems to strengthen the marketing position of the CT6 as an organized bloc, in particular:

- 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/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 exportation of corals owing to their huge direct fisheries value and large, critical ecosystem service values for coastal protection and climate change adaptation;
- 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 CT countries;
- Allocate revenues from fisheries to invest in social enterprises, which capacitate fishers to improve incomes through sustainable fisheries yield practices, and in enabling mechanisms that empower them to access information and capacity building opportunities;
- Promote the social marketing of the 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 numbers 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 (subsistence fisheries or the subsistence fisheries sector) in spurring local economies and develop methods to derive relevant statistics at the national and regional scale

In conclusion, the ecosystem approach to fisheries management requires coordinated coastal and ocean resources governance at the local, national, and regional scales in order to overcome the challenges of fisheries overexploitation, degraded ecosystems, and decline of goods and services. Sustaining the 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 the CTI's goals as enunciated in the RPOA and NPOAs.

Appendix 1

LIST OF SPECIES IN THE CT6 WITHIN THE FAO LANDINGS DATASET, 1950s–2010[67]

CT FAO Landings (ASFIS Species)	Ecosystem	Taxonomy	Human use	*Groups not in Newton *et al*., 2007
Abalones nei	demersal marine	mollusc	Consumed	
Akiami paste shrimp	demersal marine	crustacean	consumed	*
Albacore	ocean	fish	consumed	
Anadara clams nei	reef associated	mollusc	consumed	
Anchovies, etc. nei	ocean	fish	consumed	
Aquatic invertebrates nei	reef associated	inv	consumed	
Atlantic white marlin	ocean	fish	consumed	
Bali sardinella	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	ocean	fish	consumed	*
Blacklip abalone	reef associated	mollusc	consumed	
Blood cockle	demersal marine	mollusc	consumed	*
Blue mackerel	ocean	fish	consumed	*
Blue marlin	ocean	fish	consumed	
Blue swimming crab	estuarine	crustacean	consumed	
Bombay-duck	ocean	fish	consumed	*
Bullet tuna	ocean	fish	consumed	*
Butterfishes, pomfrets nei	ocean	fish	consumed	
Carangids nei	reef associated	fish	consumed	
Cephalopods nei	ocean	mollusc	consumed	
Chocolate hind	reef associated	fish	consumed	*
Chub mackerel	ocean	fish	consumed	
Clams, etc. nei	reef associated	mollusc	consumed	
Clupeoids nei	ocean	fish	consumed	
Cobia	reef associated	fish	consumed	
Commercial top	demersal marine	mollusc	traded	*
Common dolphinfish	reef-associated	fish	consumed	
Common squids nei	ocean	mollusc	consumed	
Conger eels, etc. nei	demersal marine	fish	consumed	
Croakers, drums nei	reef associated	fish	consumed	
Cupped oysters nei	mangrove	mollusc	consumed	*
Cuttlefish, bobtail squids nei	reef associated	mollusc	consumed	
Daggertooth pike conger	demersal marine	fish	consumed	*
Demersal percomorphs nei	demersal marine	fish	consumed	

[67] Based on Newton *et al.* (2007) and FishBase (Froese and Pauly, 2013).

CT FAO Landings (ASFIS Species)	Ecosystem	Taxonomy	Human use	*Groups not in Newton ***et al***., 2007
Dogfish sharks nei	reef associated	elasmobranch	consumed	*
Eagle rays nei	ocean	elasmobranch	consumed	*
Eeltail catfishes	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	estuarine	fish	consumed	*
Flyingfishes nei	ocean	fish	consumed	
Fourfinger threadfin	demersal marine	fish	consumed	*
Frigate and bullet tunas	ocean	fish	consumed	
Frigate tuna	ocean	fish	consumed	*
Fusiliers nei	reef associated	fish	consumed	
Gastropods nei	reef associated	mollusc	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	ocean	fish	consumed	*
Greasy grouper	reef associated	fish	consumed	*
Great barracuda	reef associated	fish	consumed	*
Greater lizardfish	reef associated	fish	consumed	*
Green mussel	freshwater	mollusc	consumed	
Groupers nei	reef associated	fish	consumed	
Groupers, seabasses nei	reef associated	fish	consumed	
Grunts, sweetlips nei	reef associated	fish	consumed	
Guitarfishes, etc. nei	demersal marine	fish	consumed	*
Hairtails, scabbardfishes nei	demersal marine	fish	consumed	
Halfbeaks nei	reef associated	fish	consumed	
Hammerhead sharks, etc. nei	ocean	elasmobranch	consumed	*
Hard clams nei	demersal marine	mollusc	traded	*
Hard corals, madrepores nei	reef associated	crustacean	traded	*
Honeycomb grouper	reef associated	fish	consumed	*
Humpback grouper	reef associated	fish	consumed	*
Humphead wrasse	reef associated	fish	consumed	*
Indian halibut	demersal marine	fish	consumed	*
Indian mackerel	ocean	fish	consumed	
Indian mackerels nei	ocean	fish	consumed	
Indian scad	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	reef associated	fish	consumed	*

CT FAO Landings (ASFIS Species)	Ecosystem	Taxonomy	Human use	*Groups not in Newton *et al*., 2007
Kawakawa	demersal marine	fish	consumed	
Largehead hairtail	demersal marine	fish	consumed	*
Leopard coralgrouper	reef associated	fish	consumed	*
Lizardfishes nei	reef associated	fish	consumed	
Longtail tuna	ocean	fish	consumed	
Mackerel sharks,porbeagles nei	ocean	elasmobranch	consumed	*
Mackerels nei	ocean	fish	consumed	
Mangrove red snapper	reef associated	fish	consumed	*
Mantas, devil rays nei	reef associated	elasmobranch	consumed	*
Marine crabs nei	estuarine	crustacean	consumed	
Marine crustaceans nei	demersal marine	crustacean	consumed	
Marine fishes nei	*	*	*	* grouped as reef-associated for
Marine molluscs nei	demersal marine	mollusc	consumed	
Marine shells nei	reef associated	mollusc	traded	
Marine turtles nei	reef associated	turtles	traded	
Marlins,sailfishes,etc. nei	ocean	fish	consumed	*
Metapenaeus shrimps nei	demersal marine	crustaceans	consumed	*
Mojarras(=Silver-biddies) nei	reef associated	fish	consumed	
Monocle breams	reef associated	fish	consumed	*
Moonfish	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	mollusc	consumed	
Pacific bluefin tuna	ocean	fish	consumed	*
Pearl oyster shells nei	reef associated	mollusc	traded	
Pelagic percomorphs nei	ocean	fish	consumed	*
Penaeus shrimps nei	demersal marine	crustaceans	consumed	
Percoids nei	ocean	fish	consumed	
Pickhandle barracuda	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	reef associated	fish	consumed	*
Requiem sharks nei	reef associated	elasmobranch	consumed	*
Sardinellas nei	ocean	fish	consumed	
Sawfishes	ocean	fish	consumed	*
Scads nei	reef associated	fish	consumed	
Scallops nei	demersal marine	mollusc	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	ocean	fish	consumed	*
Sergestid shrimps nei	demersal marine	crustaceans	consumed	
Sharks, rays, skates, etc. nei	ocean	elasmobranch	consumed	
Short mackerel	ocean	fish	consumed	

CT FAO Landings (ASFIS Species)	Ecosystem	Taxonomy	Human use	*Groups not in Newton *et al*., 2007
Short neck clams nei	demersal marine	mollusc	consumed	
Shortbill spearfish	ocean	fish	consumed	
Shortfin mako	ocean	elasmobranch	consumed	
Sillago-whitings	demersal marine	fish	consumed	
Silver grunt	reef associated	fish	consumed	*
Silver pomfret	ocean	fish	consumed	*
Silver sillago	reef associated	fish	consumed	*
Silversides(=Sand smelts) nei	freshwater	fish	consumed	
Skipjack tuna	ocean	fish	consumed	
Slipper cupped oyster	mangrove	mollusc	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	reef associated	fish	consumed	*
Spotted sicklefish	reef associated	fish	consumed	
Squillids nei	ocean	crustaceans	consumed	
Stingrays, butterfly rays nei	demersal marine	elasmobranch	consumed	*
Stolephorus anchovies nei	ocean	fish	consumed	
Striped bonito	ocean	fish	consumed	*
Striped marlin	ocean	fish	consumed	
Surgeonfishes nei	reef associated	fish	consumed	
Sweetlips, rubberlips nei	reef associated	fish	consumed	*
Swordfish	ocean	fish	consumed	
Terapon perches nei	reef associated	fish	consumed	*
Threadfin breams nei	reef associated	fish	consumed	
Threadfins, tasselfishes nei	reef associated	fish	consumed	
Thresher sharks nei	ocean	elasmobranch	consumed	*
Tonguefishes	estuarine	fish	consumed	*
Torpedo scad	reef associated	fish	consumed	
Triggerfishes, durgons nei	reef associated	fish	consumed	
Trochus shells	reef associated	mollusc	consumed	
Tropical spiny lobsters nei	reef associated	crustaceans	consumed	
Tuna-like fishes nei	ocean	fish	consumed	
Turban shells nei	demersal marine	mollusc	traded	*
Various squids nei	ocean	mollusc	consumed	
Wahoo	ocean	fish	consumed	
Whitespotted wedgefish	demersal marine	fish	consumed	*
Wolf-herrings nei	reef associated	fish	consumed	
Wrasses, hogfishes, etc. nei	reef associated	fish	consumed	
Yellowfin tuna	ocean	fish	consumed	
Yellowstripe scad	reef associated	fish	consumed	*

Appendix 2

CAPTURE FISHERIES IN TIMOR-LESTE: REPORT OF A SURVEY

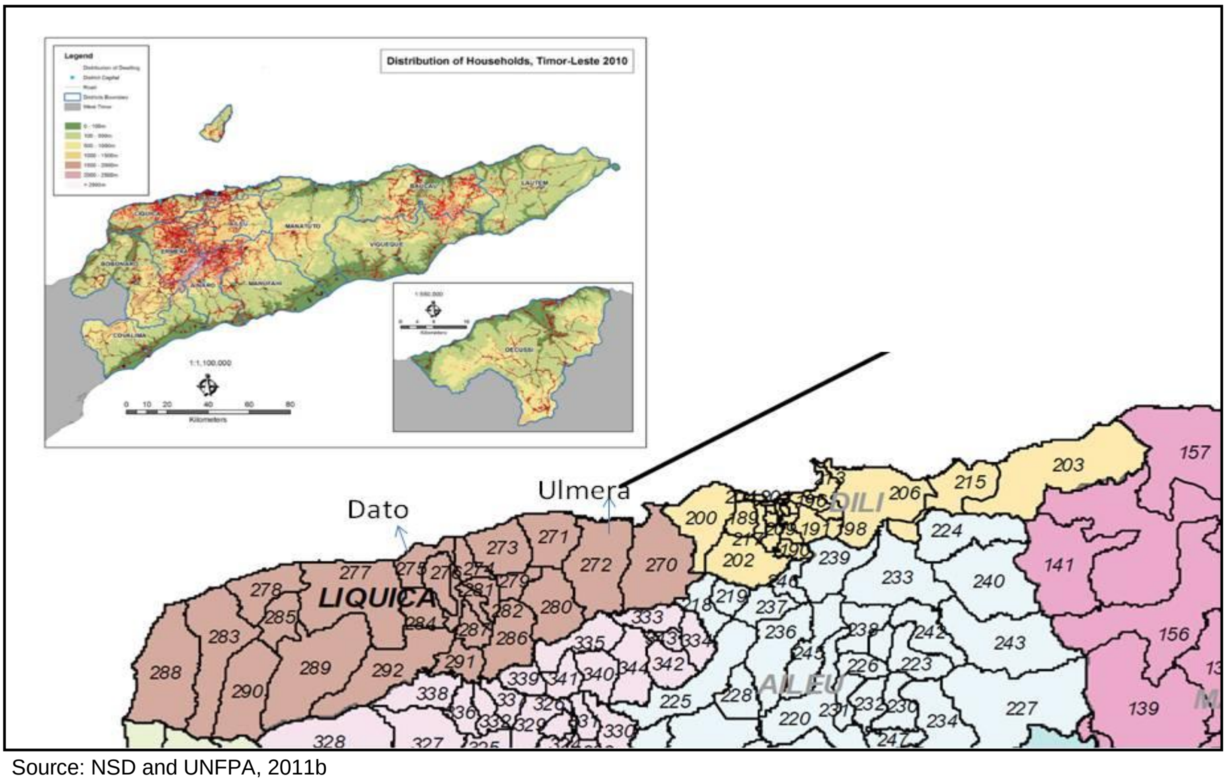
A. Background

In the late 1990s, when political turmoil ravaged Timor-Leste (at the time, a province in Indonesia), much of the fisheries infrastructure was destroyed, including fishing vessels and gear (Kalis, 2010). A 2001 survey estimated there were only about 800 seaworthy vessels, whereas in the last record by Indonesia, there were 20,027 wooden canoes and 160 motorized vessels (McWilliams, 2003). It was only in the mid-2000s that systematic development of the fisheries sector was possible in Timor-Leste, including the recording of fisheries data.

In 2005, it was estimated that there were close to 5,000 fishers in the 151 fishing centers in the country. By 2009, the number was estimated to be about 6,360 people, with about 2,177 non-motorized and 615 motorized vessels (Kalis, 2010). A national boat census during October 2011-2012 registered 2,865 boats nationwide, of which 1,324 were issued licenses (FAO, 2012).

A survey of capture fisheries households was conducted in August 2012 in the Liquica District, Dato subdistrict, Leopa and Camalehohoru Aldeia (villages), about three hours west by car from Dili, the capital (**Fig. A2-1**). The survey was aimed at (i) determining the level of dependency of households on fisheries-related activities for their livelihood at the village level, and (ii) enhancing the capacity of the Ministry of Agriculture and Fisheries (MAF) to design, plan, and implement a national fisheries household census. The survey was funded under the ADB Knowledge Management Project. The results of the survey are presented below.

Figure A2-1: Map of Timor-Leste and the Survey Area



Source: NSD and UNFPA, 2011b

B. Findings of the Survey of Capture Fishing Households

1. Demographic and Socioeconomic Features

In 2010, the total population of Dato subdistrict was 8,109 in 1,221 households (HHs) (average HH size, 6.7 persons). The total combined population of Camalehohoru and Leopa in 2010 was 5,075 across 764 HHs, or an average of 6.6 persons per HH (NSD and UNFPA, 2011a). Some 32 fishing HHs were randomly chosen from a list of more than 100 fishing HHs involved in capture fisheries in these two villages. Interviews were conducted with the HH head or in his/her absence, the HH members most knowledgeable about the fishing activities undertaken by HH members.

The population of these 32 HHs was 274 people, averaging 8.6 persons per HH. This figure is considerably higher than the Dato subdistrict average (6.7 persons/HH) and the national average (5.7 persons/HH). Other socioeconomic features of the surveyed HHs are provided in **Table A2-1** and compared with the national average.

Table A2-1: Demographic Characteristics of Respondents vis-à-vis National Values

Description	Survey (%)	National (%)
Population over 5 years old and highest educational attainment		
- Never attended school	22	34
- Primary or pre primary (finished or not finished)	45	35
- Pre-secondary	13	11
- Secondary	16	14
- Polytechnic (1-3 years)	2	1
- University	2	3
Household by type of ownership of housing unit		
• Individual owned	97	92
• Others	3	8
Households by type of materials for wall		
• Concrete/brick	66	30
• Wood	0	4
• Others	34	66
Households by type of material for roof		
• Corrugated iron/zinc	84	67
• Others	16	33
Households by type of material for floor		
• Not soil	60	41
• Soil	40	59
Households by main source of energy for cooking		
• Wood	97	90
• Others	3	10
Households by main source of energy for lighting		
• Electricity	81	34
• Others	19	66
Households by main source of drinking water		
• Pipe (indoors, outdoors, public tap)	41	45
• Well	50	20
• Others	9	35
Households by main type of human waste disposal		
• Own facility	66	NA
• No facility or bush	25	36
• Others	9	28
Households involved in other livelihoods		
• Agriculture (crop production and livestock keeping)	84	NA
• Crop production	NA	63
• Livestock keeping	NA	86

NA = not available

The educational attainment of the survey households is relatively better than the national average, with a fewer people who had never attended school, and a higher proportion with primary or pre-primary level education. A higher proportion of households also owned the house they lived in. The housing and facilities conditions were better than the national average as well. Some specific features of the 32 fishing households surveyed with regard to their fishing activities and the level of their dependency on capture fishing are as follows:

- Only two households engage in regular fish harvesting without using a boat; 20 households use medium or small non-motorized boat, whereas 16 households use medium or small motorized boats. Only one household uses a large (>7 m) motorized boat.
- All households use wooden boats.
- All households conduct fishing as one family/household unit, and none combine one or more households; no one works as a laborer in other households or commercial boats.
- All craft/gear are owner-operated; some boat and gears were obtained through government grant programs but are owned by the operator (not lent).
- In the 32 households, 42 people engage in fishing regularly, of whom 27 (56%) fish every day (at least six days per week), 13 (41%) fish two–five days per week, and 19% fish one day per week or less.
- Almost all catch is sold or consumed fresh.
- The main gears used are the gill net and hook and line, which are used by 31 or 32 households. Five households (16%) use spears and three (9%) use bottom longlines. One household uses a shark hook (large, heavy-duty hook), and one uses a fish sounder lent by an FAO program.
- Average monthly revenues from selling harvested fish for the months of May, June, and July 2012 were $1,282, $175, and $216, respectively;[68] average total cost of fishing for the three months was $263. Therefore, average net income was $1,410 for three months or about $470 per month. However, there are wide differences in income among fishers, ranging from –$266 to a high of $1,248.
- About 75% of the households (24) also depend on other agriculture-related activities including crop planting and livestock keeping. A little more than half (53%) indicated that fishing is their main form of livelihood.

A summary of the August 2012 survey results is shown in **Table A2-2** (middle column). Based on the FAO and WorldFish (2008) nomenclature of categories of fishers, it is clear that survey respondents fulfill most of the criteria for subsistence fisheries (refer to rows with check marks). There are only two criteria that do not meet the subsistence fisheries categories, i.e., the disposal of catch, where the surveyed respondents' catch is primarily for sale, with a portion for domestic/own consumption; and integration into the economy: much of the fishing and disposal are via market channels (e.g. the local wet market or by vending on the side of the road).

Given the lack of national statistics for the points in **Table A2-2**, subnational reports and analysis (left-most column in **Table A2-2**) were used. Overall, the profile indicates that there is reason to argue that subsistence fisheries dominate (refer to rows with a check mark) in the survey area, while there are sites with larger scale and more commercial fisheries.

Table A2-2: Categories and Characteristics of Fisheries in Timor–Leste

Characteristics	Subsistence Fisheries*	Survey (August 2012)		Regional or National[a]	
Size of fishing craft/vessel and engine	None or small (5-7 m; <10 gt) usually non-motorized	62% of households operate small or medium (up to 7 m) non-motorized boats; 50% of households operate small or medium motorized boats (up to 15 hp); only 3% (one household) uses a large boat (>7 m)	✓	78% of vessels are without engine (2009)[b]; in a regional survey in five districts, 82% use wooden non-motorized 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	NA	Mostly gill net and hook and line; virtually all manual gears		Out of an estimated 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% use beach net, 34% use fish net, and 31% use gill net. [c]	

68 June to August are lean months for fishing in the survey area.

Characteristics	Subsistence Fisheries*	Survey (August 2012)		Regional or National[a]	
Fishing unit	Individuals, family or community groups	All households conduct fishing as a family unit; almost all 1-2 people	✓	Nationally, except for the large-scale fishers in Atauro Island, most conduct fishing as a family unit (2009)[b]; 76% fish in small groups of 2-5 fishers; 23% 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% rented; 4% borrowed.[c]	✓
Type of commitment	Mostly part-time/ occasional	More or less 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;[c] 54% spend less than 6 hrs/trip; 22% spent 6-12 hrs; 16%, 12-24 hrs; 6% spend two 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.	✓	NA	
Disposal of catch	Primarily household consumption but some local barter and sale	Primarily for sale and some for household consumption; 63% sell at fishing centers; 31% sell on the roadside, on the beach, at local market, etc.		A regional survey in five districts found that 27% fishers sell their catch at a local market.[c]	✓
Utilization of catch	Fresh or traditionally processed for human consumption	Almost all sold or consumed fresh	✓	A regional survey in five districts showed that 60% of catch are sold as fresh product,[c] 36% process a small portion of catch before selling (traditional processing method);[c] outside of Dili area and Atauro Island area, very limited use of ice for preservation.[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]	

* FAO and WorldFish Center (2008).
[a] Source: Kalis (2010).
[b] National description based on Kalis (2010).
[c] Regional description (for 5 districts) based on Amsat (2011).
Note: A check mark (✓) indicates that the characteristic is typical of subsistence fisheries.

2. Catch Utilization

The survey of capture fishers included catch volume, species, and average price for the months of May, June, and July 2012, which was reported by respondents as the lean season. There was a large variability in the volume of catch across the surveyed households. Below is a description of the catch of two respondents representing fishing households with the largest and the smallest revenues.

The highest gross revenue over the three-month period was made by HH 21, which owns three boats: two of medium size (5–7 m) and one of small size (<4 m), all with outboard motors. In the household, there is one active fisher fishing with members of other households (family and/or friends). The boats that are not being used by the owner are rented out to other fishers. The catch volume and revenue as estimated by the fisher can be seen in **Table A2-3.** Total gross revenue for three months was $11,510, although most was obtained in May, when 80 fishing trips were made (more than one trip per day using alternate boats). Fishing comprises the main source of income for this household.

Table A2-3: Harvest by the Highest Grossing Household

Month	Number of Trips	Name of Fish	Volume (Various)		Value (USD)	
			Average per Trip	Total for the Month	Average per Trip	Total for the Month
(1)	(2)	(3)	(4)	(5)	(6)	(7)
May	80	*Terbang* (Flying fish)	25 kg	2,000 kg		6,000
		Sardin (Sardine)	7 kg	560 kg		1,680
		Sember	25 kg	200 kg		600
		Kerapu (Grouper)	5 strings	400 strings		1,200
		Kakap (Snapper)	5 strings	400 strings		1,200
		Alu-alu (Barracuda)		1 fish		10
		Tenggiri (Mackerel)		6 fish		60
		Total				10,750
June	10	*Terbang* (Flying fish)	2.5kg	25 kg		100
		Kakap (Snapper)	5 strings	50 strings		100
		Kerapu (Grouper)	5 strings	50 strings		100
		Sember	4 strings	40 strings		80
		Total				380
July	10	*Terbang* (Flying fish)	5 strings	50 strings		100
		Kakap (Snapper)	5 strings	50 strings		100
		Kerapu (Grouper)	5 strings	50 strings		100
		Sember	4 strings	40 strings		80
		Total				380
	Grand Total			**Various**		**11,510**

Note that as a measure of volume of harvest, it is common for fishers to use different units of measurement. Usually, 'kilogram (kg)' is used when catch is sold to wholesalers (who have a weighing scale with them), whereas the rope/string (*ikat*) (**Fig. A2-2**) is used for local retail sale. One string of fish is usually made up of the same species, and fishers group the fish together to make several strings of about the same weight, which they then accord the same price. It is difficult to know the exact weight in kg as the number/size of the total fish in a string can vary with season, even if their price remains the same (i.e., a $2 string of mackerels in July may weigh differently than a $2 string in April). Larger fish such as the barracuda are usually sold per piece.

For the lowest grossing household, we excluded those households who did not have a member participating in regular fish capture (less than 10 times in total for the 3 months). As mentioned above, the months of March – July were low season for fishers, and in several households, fishers in the family switched to other occupation during that time.

Figure A2-2: Rope/string (*ikat*) commonly used in local retail sale of fish

The lowest grossing household was HH No. 20, which owns one non-motorized medium-size boat. The active fisherman in the household was at sea during the interview, so the father and wife, who are responsible for disposal of the fish (through domestic consumption or selling), were interviewed instead. The types of fish caught seem to be similar, albeit of lesser variety than the first household. The respondents did not remember the volumes of catch, but could estimate the earnings for the months in question (**Table A2-4**). The total gross revenue for the three months was $130, a far cry from the highest grossing household above. Fishing, however, is not the main source of income of this family, but rather other agricultural activities such as growing of garden fruit and vegetables, and raising of livestock.

Table A2-4: Harvests of the Lowest Grossing Household

Month	Number of Trips	Name of Fish	Volume (Various)		Value (USD)	
			Average per Trip	Total for the month	Average per Trip	Total for the Month
(1)	(2)	(3)	(4)	(5)	(6)	(7)
May	30	*Kakap* (Snapper)				
		Terbang (Flying fish)				
		Total				
June	30	*Terbang* (Flying fish)				
		Tenggiri (Mackerel)				
		Total				
July	30	*Terbang* (Flying fish)				
		Alu-alu (Barracuda)				
		Total				
	Grand Total					1

The survey also looked into the method of disposal of catch for the last fishing trip taken. For HH No. 21, the largest grossing household, the distribution was: 18 strings sold at the landing site, 1 string consumed during fishing activity at sea, and 1 kg distributed among the crew. For HH No. 20, the lowest grossing household, the whole catch of about one string of fish was used for own household consumption.

3. Community Dependency

In addition to the survey of capture fisheries fishers, a village census was undertaken. The objective of the census was to cover all households within a prescribed area and enumerate those households with at least one member engaged in capture fisheries, aquaculture, or salt harvesting. The village chosen was Aldeia Mane Mori in the Ulmera District of Timor-Leste. Mane Mori is located about 1.5 hrs drive from Dili and is a small village with a narrow beach lined with mangroves. Households in the community engage in a relatively wide array of ocean-related livelihoods, i.e., capture fisheries, seaweed farming, grouper growout, crab collection and growout, and salt harvesting.

Official Aldeia records indicate 60 households registered. The survey, however, found more than 60 dwellings and interviewed 59 households (three households were not interviewed since their members were away during the time of the interview).

The village census showed that of the 59 households interviewed, 33 (56%) households did not have anyone engaged in capture fisheries or aquaculture. About 18% of the 59 households have at least one member of the household engaged in capture fisheries, and about 25% in aquaculture. Four households (7%) have at least one member engaged in both capture fisheries and marine aquaculture. Therefore, overall, the community dependence on fisheries is high—slightly less than half of the households are dependent on livelihood sources in the fisheries sector.

At the household level, dependence on fisheries as a source of livelihood varies. For those engaged in aquaculture (11 households), it is the main source of income. For those engaged in both aquaculture and capture fisheries, it is 50-50; all households indicate that fisheries are their main source of income, although they cannot attribute percentages to either aquaculture or capture fisheries. They indicate, however, that aquaculture provides a more stable source of income than does fishing.

In addition to selling fish, most households retain a portion of the catch for their own consumption. The survey was conducted during the low season in fish harvesting, when most of the catch is consumed domestically. During the time of the survey, more than 50% of catch was kept for household consumption on average. During the peak fishing season, however, the percentage could be as low as 2% (2 out of 100 fish caught) or no fish was kept.

Although the survey was done during the lean season, several fishers were able to catch large amounts of fish, yielding relatively high income. One household of nine members owning three boats earned more than $12,000 during these three months.

The incomes of families from fisheries are relatively high. Seaweed harvesting is notably more stable in yielding a stable income stream. However, the cost of living in Timor-Leste is quite high, and income from fisheries is spent to buy meat, vegetables, and rice, which most households do not produce themselves. One small household of five in Mane Mori routinely (every two–three weeks) earns $200–$400 from selling their harvested seaweed in Dili. However, the family lived in a very modest dwelling with dirt floor and thin, non-cement walls, and their children were poorly clothed.

C. Summary

Given the heterogeneous makeup of the fishing households in Timor-Leste, it is difficult to infer generalizations at the national level. In 2010, Timor-Leste conducted a national population census, but although the census covered a range of agricultural indicators, fisheries was not included. The government is planning a fisheries census in the near future. Meanwhile, some information collection has begun. Perhaps the most significant is the boat census that was completed in October 2012 and supported by FAO. Additionally, data gathering at key landing sites has started, using a standardized method and unit of measurement (kg). Hopefully, in one or two years, additional and more reliable information will be available through these efforts.

The survey and the secondary data collected during this study indicate that *first* of all, Timor-Leste households are dependent on fisheries although perhaps not as high as expected. Fishing households have a variety of livelihoods, including agriculture and husbandry. This situation is somewhat different from that in neighboring Indonesia, for example, where fishers do not generally engage in such extensive farming practices, perhaps due to the lack of land.

Secondly, 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 there, either directly or indirectly through wholesalers. However, the surveys in Dato and Ulmera 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, it is clear that even the smallest and most manual fishing unit has the opportunity to earn cash from sale of harvest at the community level. *Thirdly*, it is worth noting that 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 (boat, nets, etc.), buying them with outright cash. Fishers also own such assets as a house and some land. Therefore, while not much can be said about the poverty level of fishing households (*vis-à-vis* households in other sectors), it is interesting to note that asset ownership and availability of capital allow for some production and earnings of cash. Perhaps the key question is whether earnings will allow for further investments in productive assets, education, and skills improvement, or are just enough to satisfy day-to-day consumption needs.

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