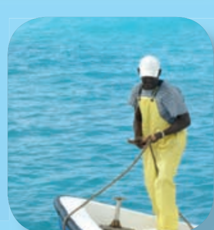
ecosystem approach to pelagic fisheries in the lesser antilles

the e.a.f

Ecosystem Approach to Fisheries



International Agreements, Conventions & Declarations Pertinent to EAF

1972 World Conference on Human Development
1982 UN Law of the Sea Convention
1992 UN Conference on Environment and Development and its Agenda 21
1992 Convention on Biological Diversity
1995 UN Fish Stocks Agreement
1995 FAO Code of Conduct for Responsible Fisheries
2001 Reykjavik Declaration on Responsible Fisheries in the Marine Ecosystem
2002 World Summit on Sustainable Development

The ecosystem approach to fisheries (EAF) is a framework for fisheries management which expands the single-species approaches of earlier fisheries management to incorporate the wider ecosystem. It does this in recognition of the fact that neither fish species nor fisheries exist in isolation. Both are embedded in an interacting network of plants, animals (including humans) and non-living components. The key conceptual difference between EAF management and conventional approaches is the focus on sustainability of all components of the ecosystem, not just those that are targetted by fisheries.

The need for this broader approach, which demands a better understanding of the structure and function of the ecosystem, has become apparent as many fisheries, including some closely managed ones, have repeatedly declined when management has tried to treat the target species in isolation. Over time, various international conventions and agreements have become clearer in their requirements for an ecosystem approach to fisheries management. This process has led to five principles to be addressed under an EAF:

- **fisheries should be managed to limit their impact on ecosystems to acceptable levels**
- **ecological relationships between species should be maintained**
- **management measures should be compatible across the entire distribution of a resource**
- **precaution in decision-making and action is needed because the knowledge on ecosystems is incomplete**
- **governance should ensure both human and ecosystem well-being and equity**

The demand for information to put EAF into practice is far greater than that required under a conventional single-species management approach. Precautionary decision-making is a key principle as important information gaps are likely to remain while key decisions must still to be made. It is critical that there is a scientifically robust approach to the process to support decision-making. This requires knowledge of the structure, function and constraints of ecosystems. The impact of fisheries may be felt beyond the target species, and it may come through direct interactions such as by-catch mortalities or indirectly through ecological linkages. Removal of a key food species by fishery or predator by a fishery can have drastic effects on a species that is not directly targeted by the fishery in question - a risk that precautionary decision-makers should seek to avoid until predator-prey relations and dependencies are better understood.

introduction.

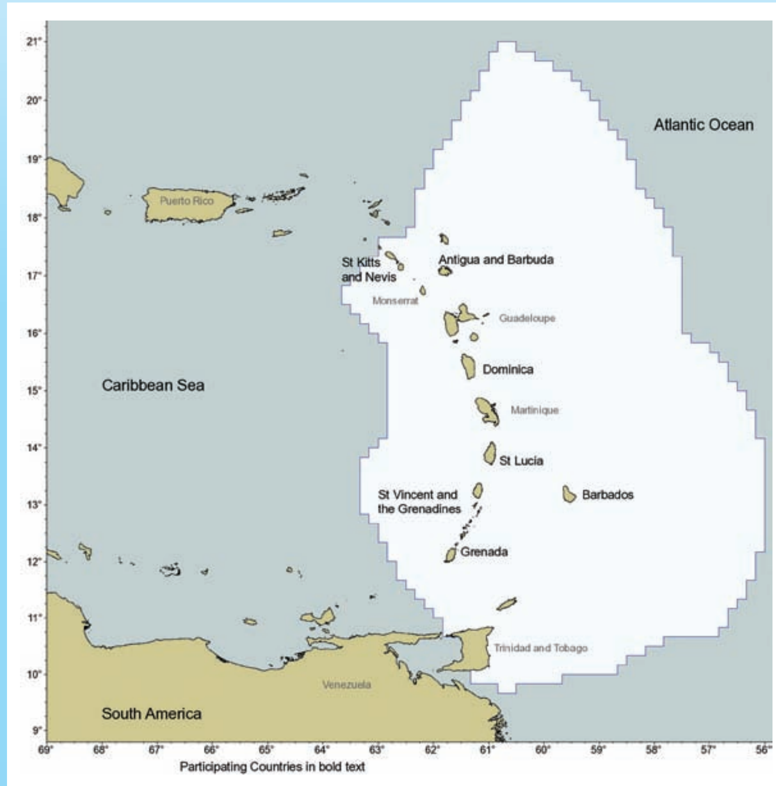
The Lesser Antilles Pelagic Ecosystem (LAPE)

The Lesser Antilles island chain is part of a long volcanic island arc, most of which wraps around the eastern end of the Caribbean Sea. The area of study of the Lesser Antilles pelagic ecosystem[1] (LAPE) encloses approximately 610, 000 km^2 within the Caribbean Marine Ecosystem. The large majority of LAPE waters are of oceanic depths of 1,000m to over 6,000m deep. Only about 2% of the LAPE study region is shelf area, that is where the bottom of the sea is less than 200m deep because of the steep-sided bathymetry of the Lesser Antillean islands.

Pelagic refers to the parts of the ocean that are not associated with bottom or coastal features. The ocean is divided into pelagic layers based on depth and the type of life found there. The two layers of the ocean that are of most interest to fisheries are the EPIPELAGIC layer, from the surface to about 200m and the MESOPELAGIC layer, from 200m to about 1,000m. In the epipelagic layer, enough sunlight penetrates to allow for photosynthesis. Light is virtually completely extinguished within the mesopelagic layer. The LAPE study focused on the epipelagic layer of the waters of Antigua and Barbuda, Barbados, Dominica, Grenada, St. Vincent and the Grenadines, St. Lucia, St. Kitts and Nevis. Associated studies included Martinique and Trinidad & Tobago.

A wide variety of species including marine mammals (whales, dolphins and porpoises), sea birds, sea turtles, fish and invertebrates can be found in the LAPE area. The LAPE is an "open" system that includes a number of large and highly migratory marine species that range far outside of the LAPE area. They include large pelagic fish such as yellowfin tuna, skipjack tuna, swordfish and billfish, as well as humpback whales, leatherback turtles and many birds. Localised pelagic species include fish like wahoo, blackfin tuna, various mackerel species and many of the smaller dolphins and porpoises. This "openness" of the LAPE means that it can be significantly affected by fisheries and other events far outside its boundaries.

[1] *defined for this study as the waters within the hypothetical Exclusive Economic Zones represented in the Global Maritime Boundary Delimitation database*



Participating Countries in bold text

challenges facing pelagic fisheries management

Most of the coastal resources in the region are fully exploited or overexploited (especially those of higher commercial value), and the demand for fish (including for tourism and recreational purposes) continues to grow. As a result, both fishers and the governments of the region are actively working to expand their fisheries for pelagic resources.

Virtually none of the Caribbean pelagic stocks are likely to be confined solely to the Exclusive Economic Zones (EEZ) of the Lesser Antilles islands. Some of these stocks will be distributed widely throughout the Caribbean Sea while others are distributed over the Atlantic Ocean. Thus, these stocks inhabit the Lesser Antilles EEZs for only a part of the time but their movements are poorly understood. Most of them will be either shared, highly migratory or straddling stocks within the context of the UN Fish Stocks Agreement, which requires some form of international cooperation for their management.

As in any ecosystem, these stocks, and many others of lesser importance to fisheries, are linked through biological interactions, such as predation and competition. There are also technological interactions between stocks such as being taken by the same fishing gear, for example the shark by-catch from tuna longlines. These interactions mean that fishing activities that influence one of these stocks are likely to influence some of the others. Both direct (fishery) and indirect (interaction) influences must therefore be taken into account when management strategies are developed and implemented for any of the fisheries.

These three characteristics of regional pelagic stocks; i) the expansion of fisheries targeting these stocks, ii) that stocks show widespread distribution throughout the sub-region and beyond, and iii) that there are significant biological and technological interactions between them; require urgent and comprehensive attention.

The countries involved requested assistance from the FAO to help develop the data and information systems necessary to assess the status of the regional pelagic ecosystem and fisheries industry, and also to make recommendations towards implementing an ecosystem approach to fisheries management. The process would also enable the countries of the region to collaborate in identifying compatible and beneficial approaches to managing and using pelagic resources throughout the region.

FAO Lesser Antilles Pelagic Ecosystem Project

The resulting FAO project was called "Scientific Basis for Ecosystem-Based Management in the Lesser Antilles including Interactions with Marine Mammals and other Top Predators" (GCP/RLA/140/JPN) which ended in 2007. More commonly referred to as the Lesser Antilles Pelagic Ecosystem Project, or LAPE project, it developed the scientific basis (data, models and recommendations) to support future management plans for an ecosystem approach to sustainable and responsible utilization of pelagic resources. The project also assisted participating countries in developing research and management capacity with the requisite skills necessary for ecosystem assessment and to support responsible and sustainable ecosystem management. Additionally, the scientific information and understanding from the LAPE project can inform emerging global and regional ecosystem issues such as the effect of climate change on ecosystems or the impact changes in long-term abundance of top predators like cetaceans, sharks and others. This report reviews the main activities, results and conclusions of the LAPE project.

the pelagic fisheries

The marine ecosystems of the Lesser Antilles are home to a wide variety of fish and invertebrates of commercial and non-commercial interest. The islands of the Lesser Antilles share a common dependence on these resources for their economic, ecological and aesthetic values. The marine ecosystem directly and indirectly impacts the economies of the Lesser Antilles on at least three levels – (i) as a primary food source, (ii) as important marketing attributes of the region's tourism product, and (iii) as an economic engine that provides employment and income opportunities for many Caribbean families.

The region depends heavily on fish for consumption both as a staple in the diet of Caribbean people and as an important element in the tourism industry. The beauty of the Caribbean Sea and its restorative powers attract many visitors to the region's shores and they expect fresh-caught local fish on the menu and, in many cases, the opportunity to catch them from sport-fishing boats. In these ways, the fisheries sector provides food, income and employment opportunities for thousands of Caribbean families. In many cases, it is the single source of income for the family with more that a million Caribbean people relying on commercial fishing for a livelihood. The foreign exchange earnings from fisheries are estimated at approximately US$1.2bn annually, with the United States the principal export destination.[1]

The fisheries of the Lesser Antilles are usually divided into related sectors, some of which are pelagic, while others are associated with reefs, shelf areas and coastal features. The northern islands of the chain, with their wider shelf and reef areas, have reef fish, lobster and conch fisheries and Trinidad, on the South American continental shelf, has major fisheries for shrimp and groundfish. However, none of these are included in the analysis of the Lesser Antilles pelagic ecosystem and its fisheries.

The pelagic fishery sectors include small coastal pelagics, flyingfish, regional large pelagics and migratory large pelagics. There are also artisanal whaling fisheries in a few localities, primarily St. Lucia and St. Vincent and the Grenadines. The dolphinfish is sometimes separated from other regional large pelagics. Its close association with flyingfish makes the fishery for this species somewhat different in practice.

Small coastal pelagics fisheries generally operate with beach seines to target small schooling species such as scads, herring and anchovies that are near shore. These catches have long been used for both food and bait. However, current growth of modern large pelagic fisheries has substantially increased the demand for bait. Flyingfish are another small pelagic species Gillnet fisheries for flyingfish (by putting out floating debris, like palm fronds to attract fish) usually operate offshore. This is an important food fishery in Barbados but is generally used for bait in other islands.

Regional large pelagics include smaller tuna species such as blackfin tuna and a number of large mackerels (e.g. king mackerel, serra Spanish mackerel) and wahoo. These species are believed to migrate between countries, but largely remaining within the LAPE area or adjacent waters. They support important food fisheries for both local and tourism consumption, and are exported as well. They are also popular targets for sportfishing by both local and tourist fishermen.

The other important group of migratory large pelagics are the billfish like blue marlin, spearfish and Atlantic sailfish. These species have long been targeted by sport and commercial fisheries with trolling or rod and reel gear. Recent fisheries for these species have

[1]Caribbean Sea Ecosystem Assessment : Executive Summary 2006, collaboration of the University of the West and the Cropper Foundation , Page 3

been dominated by the growth in regional longline fleets and are now primarily export-oriented. Sharks are also landed frequently as by-catch of large pelagic fisheries.

Pilotwhales known locally as blackfish, humpback whales and a variety of small dolphins are targeted by whalers in St. Vincent and the Grenadines. Whalers in St. Lucia also take a variety of small dolphins in their fishery. Statistics on these fisheries are limited but there are reports of up to 10 other species in by-catches including sperm and killer whales, but dolphins makes up the bulk of the whaling by-catch.

Fisheries Key

Minor — Important — Very important

Growing ↑ — Declining ↓

Country	Non-pelagic Fisheries	Small Coastal Pelagics	Flyingfish	Dolphinfish	Regional Large Pelagics	Migratory Large Pelagics	Marine Mammals
Antigua & Barbuda	Very important	Minor		Minor	Minor	Minor	
St. Kitts & Nevis	Minor	Important		Important	Minor	Minor	
Dominica	Minor	Very important	↓ Very important	↓ Very important	↑ Very important	↑ Very important	
Guadeloupe & Martinique	unknown	Very important	Minor	Important	Very important	Minor	
St. Lucia	Minor	Very important	Important	Important	Very important	Important	Minor
St. Vincent & The Grenadines	Minor	Very important	Minor	Important	Important	Important	Minor
Barbados	Minor	Minor	Very important	Very important	↑ Minor	↑ Very important	
Grenada	Minor	Very important	Minor	Important	Important	Very important	
Trinidad &	Very important	Minor			Very important	Very important	
Tobago		Very important	Important	Important	Very important	Very important	

ecosystem informatio

Surveys, studies and published sources

Single-species fisheries management, the long- time standard approach, concerns itself mostly with the target species of commercial interest. The information requirements for this management approach include catch by species (in units of weight per year); some knowledge of the growth and production of the stock, usually derived from fisheries data; and in some cases seasonality or environmental responses of the population. Information requirements for ecosystem-based management are more demanding and a model of the entire functioning ecosystem, not just the species of interest may be used to address this. Such models require all the same information needed for single-species assessment for all species of commercial interest, as well as information on the abundance and productivity of a whole gamut of non-commercial species.

Many commercially exploited species have been analysed in stock assessments to estimate the abundance (or equivalently the biomass), the rate of fishing and the expected growth (or reduction) in population resulting from changing fishing rates. All of this information is useful in representing these species in an ecosystem model. Unfortunately, assessments of this nature are not available for many important commercial species and virtually none of the non-commercial ones in the region. Required information was therefore obtained by two approaches, either from directed studies during the LAPE project or estimated in the modelling process.

A unique requirement of ecosystem modelling is the need for information to describe the ecological linkages between the various species. This primarily means trophic linkages (predator-prey linkages) which are identified by analyzing the diet composition of the consumer fish groups. Although other ecological interactions exist, for example - habitat interactions, none of these were considered important in the LAPE context.

The LAPE project conducted five types of studies to address these information needs:-

- Analysis of existing databases for fisheries
- Literature reviews of stock assessment reports
- Abundance or biomass surveys
- Literature reviews of published diet studies
- Field studies of predator diets.

fisheries data

There were limited data available on basic catch volumes, species composition, fishing effort and economic performance of the LAPE regional fisheries. The project used those data that were available in national databases as well as reports or digests of national fisheries agencies. Additionally, data from international databases maintained by FAO and the International Commission for the Conservation of Atlantic Tunas (ICCAT) were analyzed. One important task of the project was estimating the fraction of large pelagics catches actually taken from the LAPE area.

stock assessments

In the LAPE model, information for tuna and billfish species was obtained from the stock assessments conducted by ICCAT. In addition, there were a few assessments of non-commercial species, like cetaceans and sea turtles, which were available because of concerns about their potentially endangered or threatened status.

surveys

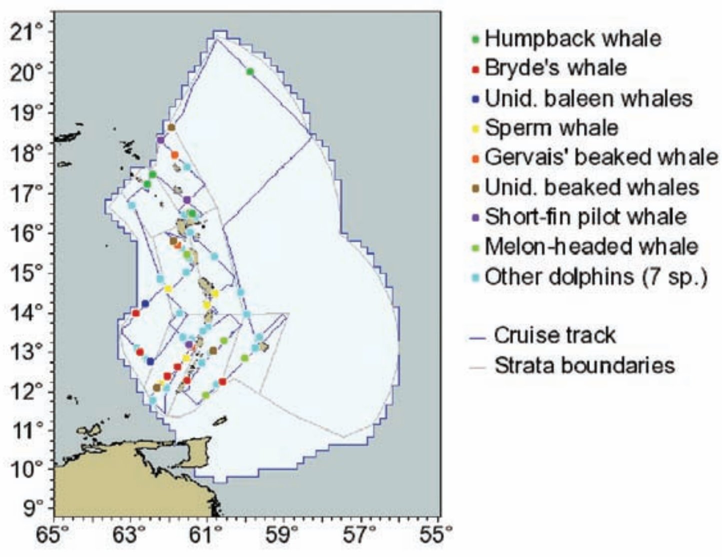
The LAPE project conducted a large-scale cetacean sighting survey in 2004 and an Ecosystem Survey in 2006. The ecosystem survey included four components; cetacean sighting, acoustic forage survey, pelagic

trawling, and oceanography and primary production observations.

Cetacean Abundance

Two large-scale cetacean surveys, conducted in 2004 and 2006, were stratified transect surveys which covered the full LAPE study area. In addition, small-scale country surveys were conducted within approximately 12 n. mi. of each participating island. These supplemented earlier small-scale surveys conducted by several countries between 2000 and 2003.

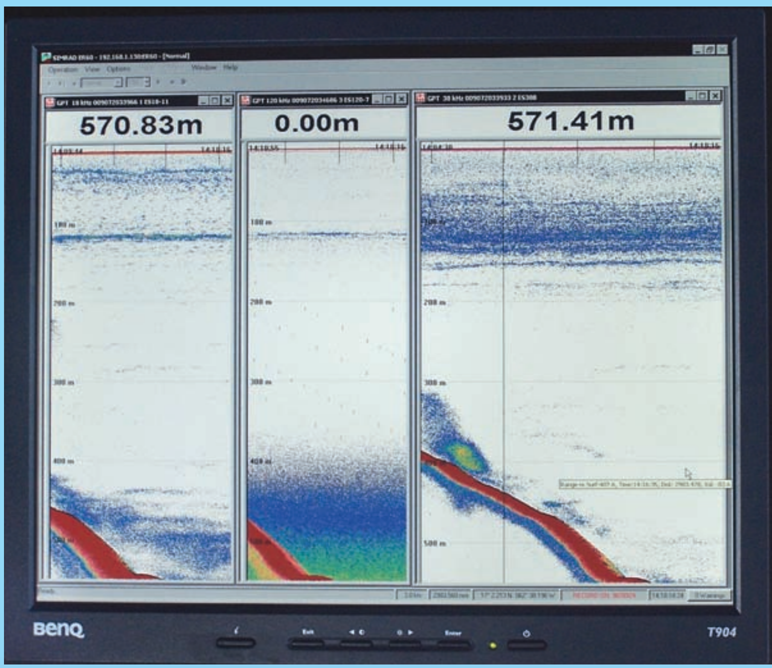
The statistical analysis of the cetacean survey results indicated that cetacean populations in the LAPE area were relatively small, a result that is consistent with other low-productivity tropical areas. These results are subject to large uncertainties because of small sample sizes.



Sightings from the 2004 large-scale cetacean survey.

Forage Biomass

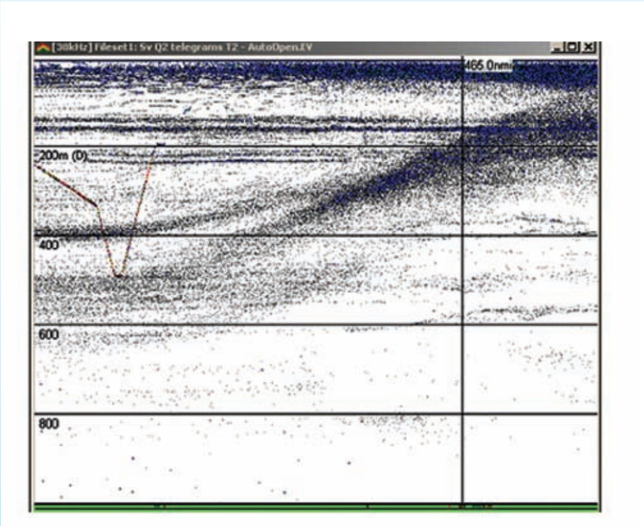
The Ecosystem Survey in 2006 combined acoustic and pelagic trawling survey results to estimate forage biomass. The acoustic system (Simrad ER60) sends 'pings' of underwater sound from a transducer under the ship's hull. It then records the strength and distance of echoes coming back to the transducer. The LAPE project acoustic survey recorded data to a maximum depth of 1000 m. However, very few targets were detected below 700 m. For most of the survey, no bottom was detected because of the great depth of the water.



Acoustic echograms at three different frequencies showing the bottom slope (dark red) with a school of fish and plankton near the bottom as well as a scattering layer at about 100 m.

After suitable analysis of these data, densities of organisms of various types and their distribution in the water column were estimated.

The acoustic data indicated that the greatest proportion of biomass in the pelagic waters was distributed in diffuse scattering layers as deep as 600 m. Dense schools of fish were rarely seen.



Acoustic echogram of the evening vertical migration of mesopelagic species upward from below 400 m to the epipelagic depths. The red trace at the left side is the echo of the oceanographic instruments being lowered and then recovered.

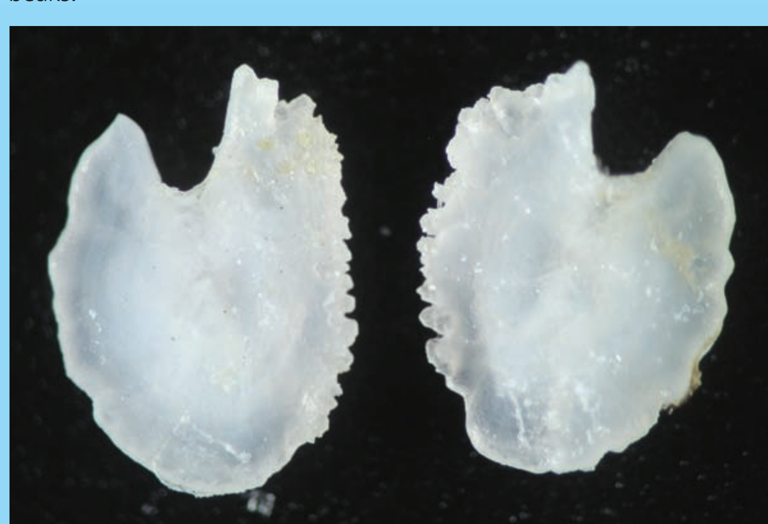
Pelagic trawling was conducted to obtain samples of the organisms detected by the acoustic sampling. Catches were sorted, identified, counted and measured by a team of regional scientists participating in the ecosystem survey. Comparison of acoustic results with catches in the pelagic trawl indicated that the biomass was made up of many species of small fish, squids and large plankton.

Sorting the catch from an epipelagic sample during the LAPE ecosystem survey.

Biomass estimates for six functional groups were obtained for use in the ecosystem model by combining the acoustic and trawl catch results. These included offshore small pelagics, coastal small pelagics, large and small mesopelagic fish, and large and small squid. The first two groups are distributed in the epipelagic layer near the surface. The other four groups all undertake daily vertical migrations from below 400 m in the daytime to the near-surface depths at night.

diet studies

The main method of determining ecological linkages is through diet analysis. The stomach contents of sampled consumers are sorted and identified to the greatest resolution possible. The objective is to estimate the proportional contribution of each prey species or group to total consumption by a consumer. This time-consuming work requires considerable taxonomic expertise as many of the prey items are identified from a few remaining bones or other hard parts. The two most common remains were fish otoliths (ear bones) and squid beaks.



Flying gurnard (Dactylopterus volitans) otoliths

As a result, local studies are almost always combined with data published in the scientific literature and other sources (e.g. www.fishbase.org). Data on over 140 species of birds, fish, cetaceans, turtles and invertebrates, taken from 131 published studies and the field studies conducted as part of the LAPE project on pelagic fish and cetaceans were analyzed to estimate the diet compositions for 29 functional groups in the LAPE trophic model.

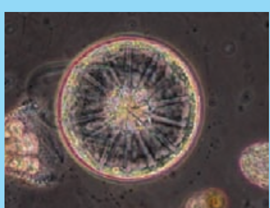
Sorted contents of a tuna stomach.

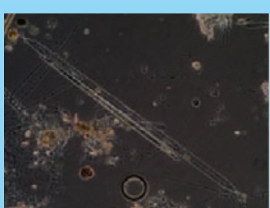
PRIMARY PRODUCTION

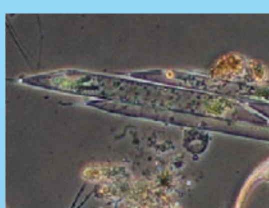
All life depends ultimately on primary producers, the organisms which capture the energy in sunlight by photosynthesis, which on land are easily recognized as plants. Although marine primary production by coral reefs, mangroves and seagrasses is relatively better known, the vast majority of primary production in the sea is by microscopic single-celled plants called phytoplankton. These tiny plants depend on sunlight in the upper pelagic layers of the ocean and absorb nutrients from the water to reproduce and grow. They are the first step in the food chain that provides the fish we eat.

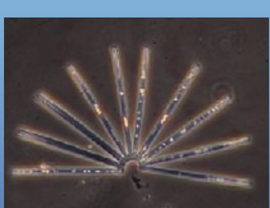
Primary production in most of the open ocean is quite low, limited by supplies of the chemical nutrients needed by plants to grow. Highly productive areas arise where sources of these nutrients are available such as deep water upwelling and large river inflows. In the LAPE, the main sources are due to the flows from the Amazon, Orinoco and other South American rivers. As all primary producers, the marine phytoplankton uses a variety of chemical pigments to capture the energy from sunlight. The best known of these is Chlorophyll, a green pigment that is present in virtually all primary producers. The concentrations of chlorophyll and other pigments in the marine plankton can be measured from space by analysing the colours coming from the oceans surface. Combining information from satellites with measurements and experiments performed at sea allows estimates of the ocean's production to be made and mapped.

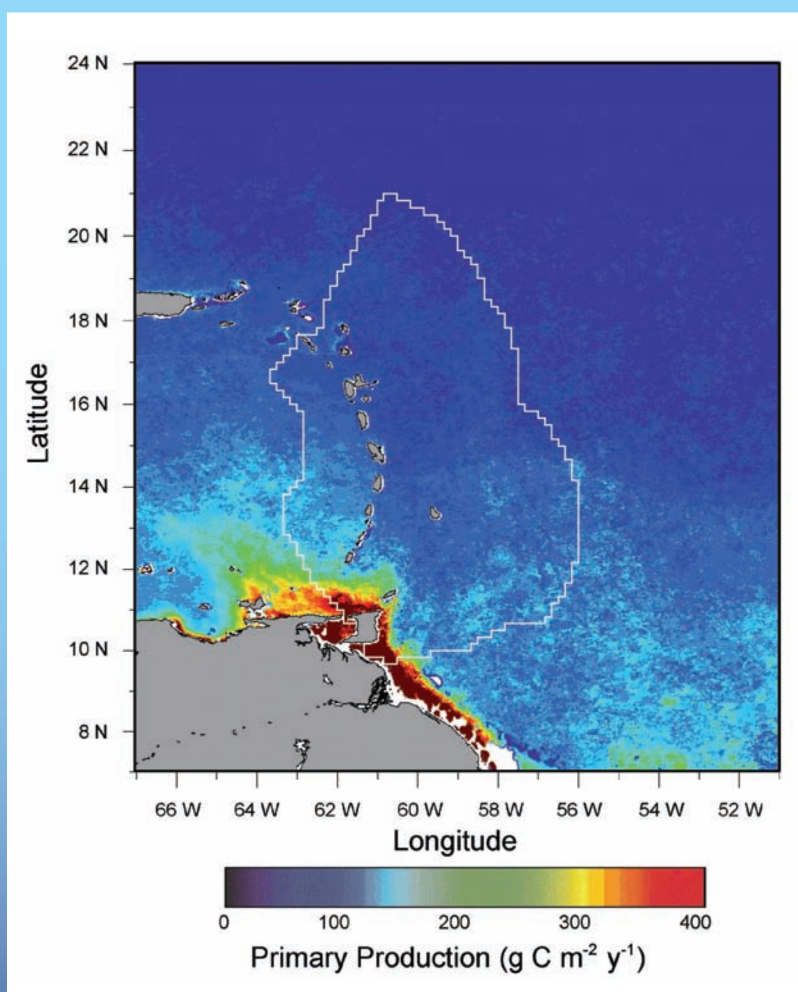
In the LAPE area, the overall primary production is quite low, consistent with other tropical open sea areas. There are seasonal variations and peaks of productivity in the southern-most area off Trinidad and Venezuela, which are driven by the nutrient supplies in the outflows of the Orinoco and other rivers.











ecosystem modelling

Ecosystem Structure & Function

Ecosystem models describe the structure and function of an ecosystem. Ecosystem structure is the set of components, functional groups that exist and interact in the ecosystem and the web of links between them. The ecosystem currency used in Ecopath models is biomass, the weight of living matter, and ecosystem function is the movement of biomass from one component to another. A functional group is made up of the members of a species, or group of species, whose ecological role is similar in that they eat the same prey and are preyed upon by the same predators. In some cases a single species may be split into two different functional groups, reflecting changes in the prey and predators of that species over its' lifetime. The Ecopath model assumes that the biomass of a functional group is in balance, that is the total biomass consumed by a functional group can be accounted for by growth and reproduction, losses to catch or predation, and attendant losses such as respiration and egestion, that is food that is consumed but not assimilated. The strict assumption of balance can be weakened by also accounting for changes in biomass due to net migration and biomass accumulation.

Thus the two master equations for each functional group in Ecopath say:

Consumption = production + respiration + unassimilated food

Production = catch + predation + net migration + biomass accumulation + other mortality

ecopath

ecopath with ecosim (ewe)

Ecopath with Ecoism (EWE) is a free ecosystem modelling software suite with three main components: Ecopath – a static, mass-balanced snapshot of the system; Ecosim – a time dynamic simulation module for policy exploration; and Ecospace – a spatial and temporal dynamic module primarily designed for exploring impact and placement of protected areas. The Ecopath software package can be used to evaluate:

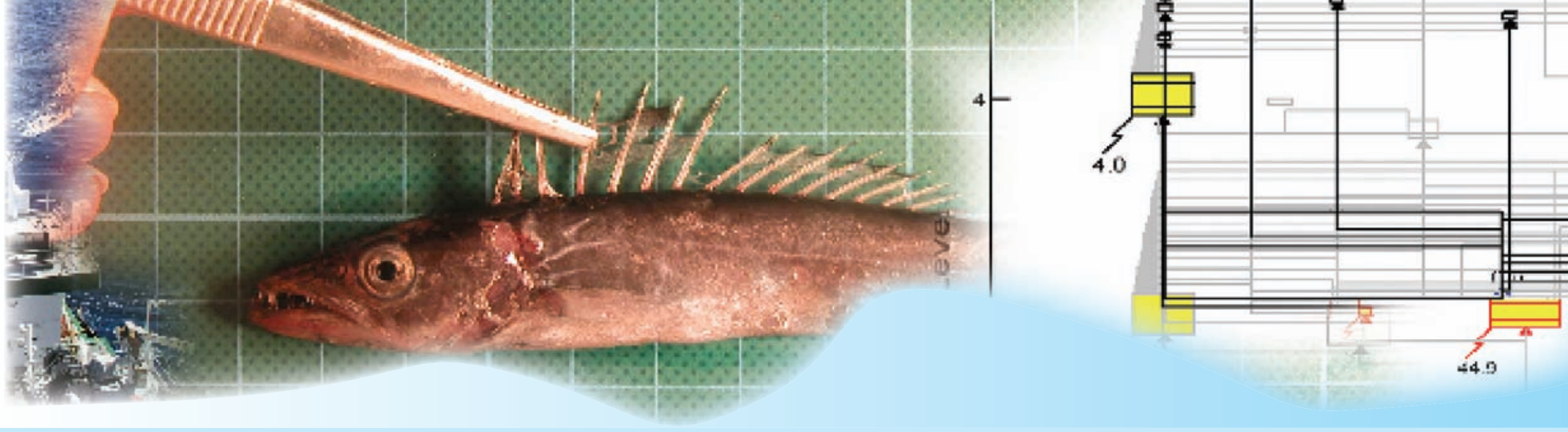
- **ecological questions**
- **ecosystem effects of fishing**
- **management policy options**
- **impact and placement of marine protected areas**
- **movement and accumulation of contaminants**
- **effect of environmental changes**

ecopath

Ecopath models are static mass-balanced snapshots of the resources in an ecosystem and their interactions, represented by trophically linked biomass 'pools' called functional groups. The biomass pools represent ecological guilds which may consist of one or more species. In some cases, a single species may be split into two functional groups, one juvenile and one adult to represent the changes in predator and prey relationships as the species grows from juvenile to adulthood. The process of constructing an Ecopath model provides a valuable synthesis of work from many researchers by bringing together scientists, researchers and data from various governments, international research organizations, universities and other groups.

fisheries management

Fisheries management aims to regulate fishing mortality and other impacts to achieve economic, social and ecological

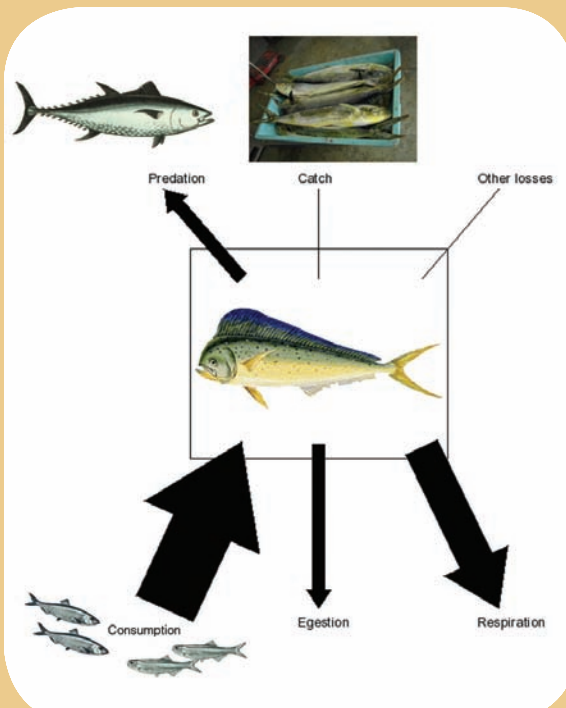


Construction of Ecopath models requires two steps. First, the structure must be defined, that is the groups within the model and the linkages between them. Estimates of the model parameters for every functional group are then needed. The two steps are often iterative with changes in structure being made as parameter estimates are being compiled.

Photo & Inset: Although the humpback whale is an important cetacean resource in the region for both tourism and fishery purposes, they are trophically separate from the LAPE.

"Go with the flow."

Each flow into or out of a functional group is represented by an arrow. The thickness of the arrow depicts the relative size of the biomass flow. The consumption flow is simply the biomass of all the prey consumed. Egestion is biomass that was consumed but not assimilated, and becomes part of the ecosystem detritus. Respiration is the portion of the biomass used to provide energy for movement, growth and reproduction. The remaining flows are the mortality sources: predation by other species (functional groups), catches by fisheries (a special case of predation) and unaccounted losses. Unaccounted mortality may be due to lack of information about predators, unreported fishing, or simply disease and senescence.



sustainability. An important modelling and assessment objective is to obtain insight about how fishing mortality rates should be regulated. We cannot expect models to provide very precise estimates of optimum fishing mortality rates, but we can expect to define reasonable and prudent ranges for the rates.

Adapted from: www.ecopath.org
The EwE software and much more information about the model are available on the website:

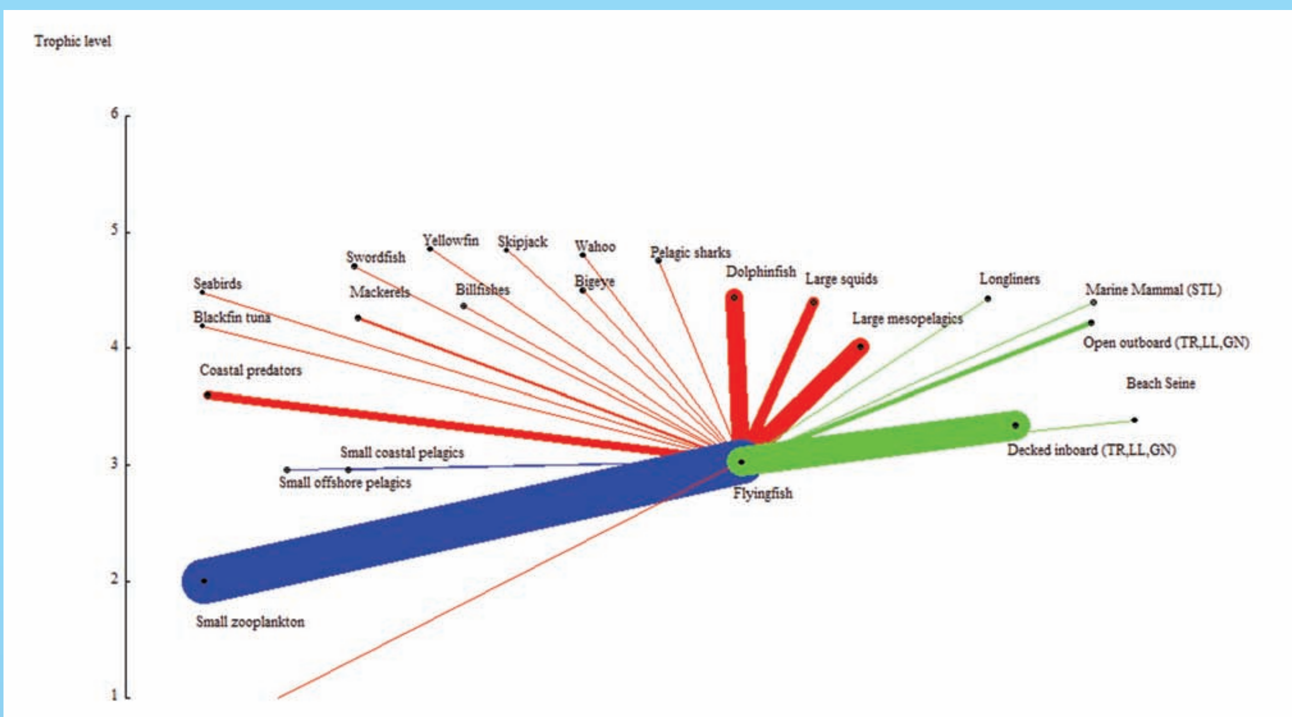
"No fish is an island."

It signifies that all organisms are linked together. In oceans for example, despite our great impact, we are only one of many predators. We must learn to behave responsibly in a realm where we are the intruders.

the lape ecosystem

The balanced Ecopath model was examined carefully to ensure that it satisfied a wide variety of constraints and sensitivity requirements. While this process cannot ensure the model's accuracy it does ensure that it is ecologically and biologically plausible and coherent There is a daunting amount of information produced from a completed Ecopath model and only a small fraction can be discussed here.

further to assess the impact on target species as part of the food web of other species and other fisheries. An important tool for this type of analysis is the Ecosim component of the modelling software. This tool allows simulation of responses of all the components in an ecosystem to changes in fisheries or the environment. Some examples follow.



An example output below shows the biomass flows to and from the species with the thickness of the line representing the magnitude of the flow. Blue lines indicate consumption of prey by the species, the red lines are consumption of the species by predators and the green lines are the catches by various fishing fleets in the model. The trophic level scale indicates the position in the food chain of each functional group.

Similar to single species stock assessments, analysis of these and other model outputs can provide insight into the relative impact of fishing on species but can also go

bait fisheries

One of the high risk issues which the LAPE project management consultations identified was the impact of increasing demand for bait with recent and continuing growth in large pelagic fisheries. Bait used by a longliner will usually out-weigh the catch obtained although the catch is far more valuable economically.

Both small coastal pelagics and flyingfish are used for bait. Substantial increases in the catches of small coastal pelagics were modeled by increasing the effort of beach

seine fisheries. Under some modeled conditions, small coastal pelagics themselves were not negatively impacted but their population could become unstable and fluctuate wildly.

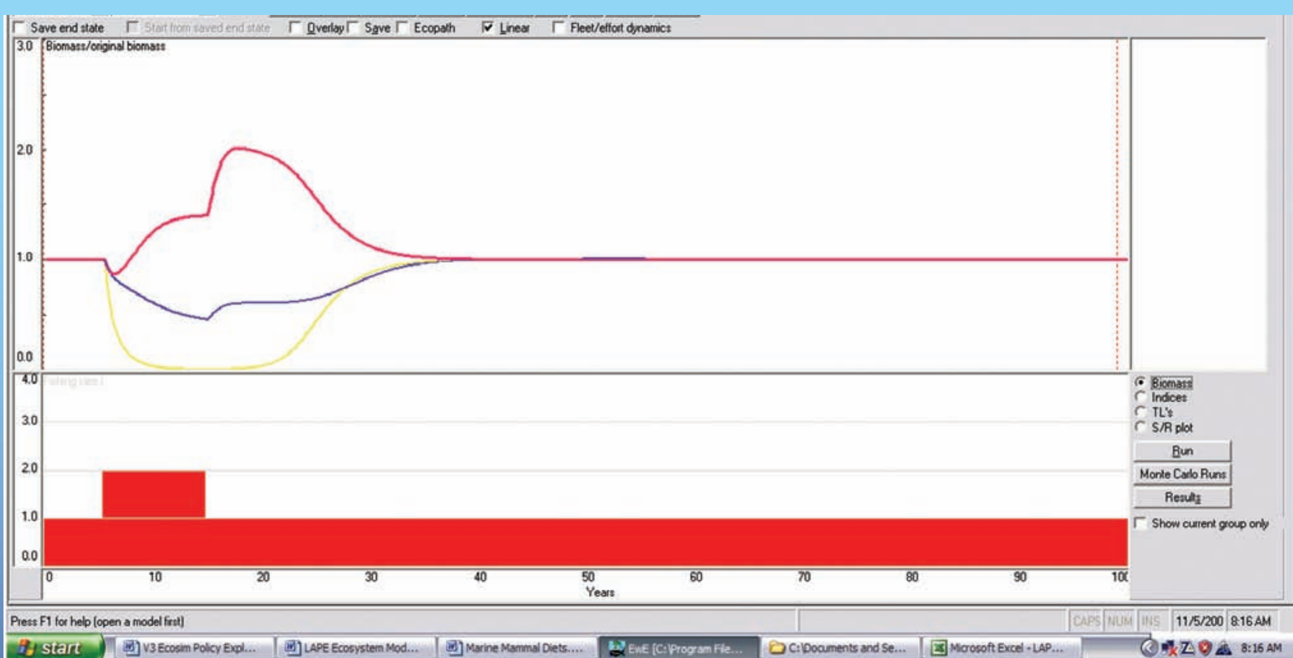
There were some significant negative impacts on other species that were either captured as by-catch in the same fishery or were dependent on small coastal pelagics for food. Under some circumstances, the biomass of small coastal pelagics could actually increase due to an intensified beach seine fishery because of the increased by-catch, and hence reduced abundance, of many of their predators.

Flyingfish

Flyingfish are in demand both as bait and as a directed food fishery. They are also a key prey item for a number of other valuable commercial species, most particularly the dolphinfish. Increasing the fisheries for flyingfish was more detrimental to dolphinfish than it was to flyingfish directly. In this case the fishery was competing with the dolphinfish for the same target species.

Skipjack-yellowfin tuna interaction

The Ecosim simulation output below shows the result of trophic linkages amongst three species in the same fishery. The fishing effort (heavy red area at bottom) was modeled to increase two-fold in 5 years. The lines in the upper panel represent the biomass of yellowfin tuna (yellow), bigeye tuna (purple) and skipjack (pink), each relative to their biomass at the start of the simulation. The simulation shows the biomass of all three species responding immediately by declining. The skipjack then increases dramatically because of the removal of predation by the other two species. When fishery effort returns to the lower level, the skipjack population is able to increase again, now due to reduced fishing mortality. The increased skipjack population then delays the recovery of the other two species as skipjack are predators of juvenile yellowfin and bigeye even though they in turn become the prey of the adults of these same species. Eventually, after 20 years of recovery, the previous equilibrium is restored.



Fisheries managemen

The Ecologically Sustainable Development (ESD) reporting framework, developed for use in Australian fisheries, was selected as a tool to structure the assessment of ecosystem issues related to the pelagic fishery in the Lesser Antilles. The framework uses a three step process:

(1) identify ecosystem issues or risks using generic component trees

(2) prioritize these issues using risk analysis

(3) develop action plans for issues rated moderate to extreme risks.

The ESD process looked at fishery issues under three main categories: ecological, social/ economic and institutional issues. Seven components were considered in the LAPE project to facilitate full assessment of the sustainability of pelagic fisheries.

Ecologically Sustainable Development Framework

Contributions of the fishery to ecological wellbeing

- Retained species
- Non-retained species
- General Ecosystem

Contributions of the fishery to human wellbeing

- Local wellbeing
- National social and economic wellbeing

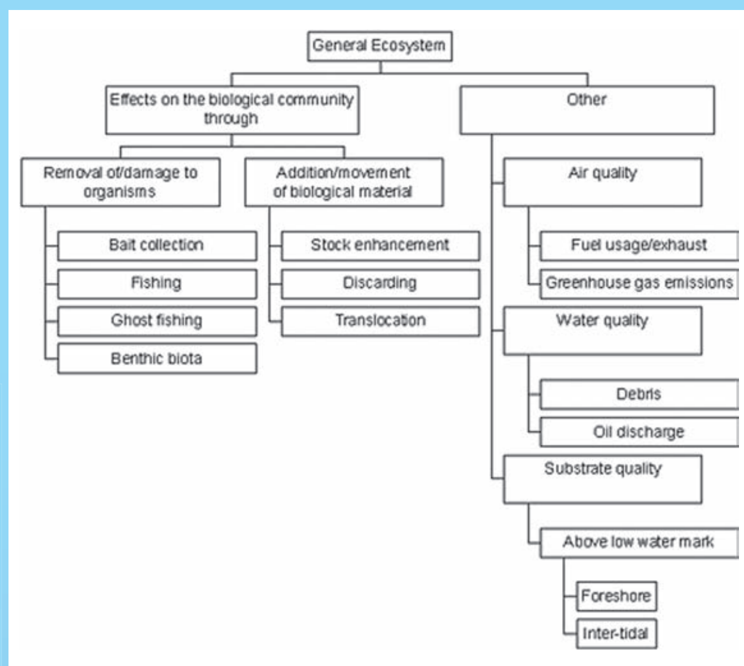
Ability to Achieve

- Governance
- Impact of the environment on the fishery

The generic component trees and associated workbooks are available on the web at: http://www.fisheries-esd.com

Each component was further divided into more specific sub-components using a 'component tree' structure as shown. A full set of generic component trees are available on the web and each can be tailored to suit the particular circumstances of the fishery, expanding, collapsing or removing sub-components as necessary within the ESD reporting framework.

The LAPE project sponsored and led multi-stakeholder national consultations which included Fisheries Officers, fishers and other participants in the industry in participating countries. In workshops lasting one and half to two days, participants identified current issues. These consultations recognized the need:



t consultations

- **to protect** biodiversity and maintain essential ecological processes, and address ecological well-being issues as they relate to the potential to overexploit, the decline of species used as bait, and proper disposal of used oil and containers

- **to enhance** enhance individual and community wellbeing through economic development, improvement of food quality standards, lifestyle changes, and development of an infrastructure maintenance philosophy at the country level

- **to provide** effective governance structures, human and financial resources, data systems, legislation and policy; facilitate stakeholder consultation and inter-agency coordination; and improve implementation, enforcement, and management of processes

Some key conclusions reached from the national consultation process were:

◆ The ESD framework facilitates inclusion of ecosystem considerations in fisheries management, consistent with international agreements and instruments

◆ There is a need to institutionalize the fisheries consultative process which is assisted by using the ESD approach

◆ Stakeholder knowledge of ecological issues needs to be reinforced through education and communication to support conservation of regional pelagic resources

◆ Greater effort is needed to document social and economic issues which must also be included in decision-making and fisheries management planning

◆ Factors leading to unsustainable practices must also be addressed to achieve the goals of economic and social benefit, sustainability, and ecosystem integrity. These include high demand for limited resources, inadequate knowledge - complicated by complexity in the ecosystem, and the lack of effective governance structures.

◆ Stakeholders rated governance issues as the highest risk to the sustainability of pelagic fisheries. Sustainability will require that countries work within regional and international organizations given that many of these resources are migratory

◆ The scientific information to inform decision-making under an ecosystem approach to the management of pelagic resources in the Lesser Antilles requires a diverse and detailed set of data, including that needed for ecosystem modelling and other assessments. Countries need to carefully consider their current institutional capacity to provide monitoring options that give good management indicators. New or reconfigured data collection systems may be required.

Recommendations

The countries of the Lesser Antilles have made some progress in implementing EAF management, often in response to specific international agreements or other ad hoc pressures. Development of comprehensive, ecosystem-wide plans, based on national and regional objectives and associated priorities, is still in preliminary stages. The LAPE project has provided a substantial body of scientific information which will allow the countries to continue the process of systematic identification, review, and priority setting of pelagic fisheries issues that were started under this project. Ideally, this should lead to formalized EAF management plans for all fisheries and ecosystems at national and regional levels.

Scientific and Technical

This project has completed an extensive compilation of existing information, generated new data, and produced a synthesis of all this information, to guide policy in support of an ecosystem approach to fisheries management for sub-regional pelagic fisheries. There are a number of data deficient areas which could be improved with relatively small additional investments.

There are also areas to be addressed which will require much more substantial and long-term investment. The project had to assess the degree to which certain large pelagic fish stocks depend on or utilize the Lesser Antilles pelagic ecosystem. The project used fisheries catch data available from ICCAT but additional data is available which should be included in this analysis to improve estimates. These include USA and Venezuela observer data as well as tagging data from over 20 years of large pelagic tagging activities.

One of the original target areas of new information generated by this project was the diet of cetaceans and other top predators in the sub-region. There is still a need for additional data in this regard but another immediate, extensive, and hence expensive, study of predator diets is not recommended. However, a relatively small level of continuing effort in this area through individual small-scale studies (e.g. M.Sc. projects) could eventually lead to a substantially improved understanding of the ecosystem structure at upper trophic levels. Such studies should be coordinated to address identified needs and to ensure that data quality standards and a central data repository are maintained over time.

At the national level, fundamental fisheries statistical data continue to be inconsistent or incomplete in many of the regional countries. Efforts to improve data collection, data management and routine analyses must continue to ensure that policy analysis and decision-making is supported by high quality and accurate information. The various national data systems must also be harmonized to a greater degree than has been the case to date, in order to make regional or sub-regional management a functioning reality.

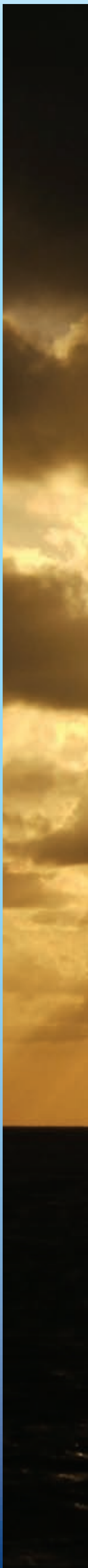
Management and Governance

The fisheries management consultations initiated by the project were well received by stakeholders and provide a starting point for more involvement of resource users in developing management objectives. This process should be integral to future planning activities for single-species and ecosystem management planning.

Pelagic fisheries are expanding, particularly in the southern countries of the region. Although this is largely consistent with policy directions taken by national governments, it will create unplanned side effects. This is highlighted by the recent development of bait fisheries to supply the growing fleets of longliners. Longline fisheries demand for bait (primarily small coastal pelagic species and flyingfish) will have implications for food security, as local consumers of low-cost fish must compete with large-pelagic fisheries for the same supply. Effective management and sustainable expansion of the region's large pelagic fisheries must not only deal with the international ramifications (e.g. involvement in ICCAT) but also the more local side-effects such as bait supply and loss of food fish from local markets.

The need for a process of consistent management activities, in particular planning, development and monitoring at the sub-regional level is also highlighted by the bait fishery A coherent Lesser Antilles perspective is needed to support management decision-making for the pelagic ecosystem of the Lesser Antilles.

The additional information demands of an ecosystem



approach to fisheries management means that further assistance with data system development, training, and in some cases, additional human resources, may be required for the Lesser Antillean countries to responsibly and adaptively manage their participation in the planning and development of regional and international pelagic fisheries.

List of project publications

FAO. 2007. *Scientific Basis for Ecosystem-Based Management in the Lesser Antilles Including Interactions with Marine Mammals and Other Top Predators: Cetacean Surveys in the Lesser Antilles* - 2000-2006, FAO, Barbados, 2007. ix + 57 pp., 11 Figures and 17 Tables, FI:GCP/RLA/140/JPN. Technical Document No. 3

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Forget, Marie-Hélène. 2007. *Scientific Basis for Ecosystem-Based Management in the Lesser Antilles Including Interactions with Marine Mammals and Other Top Predators: Phytoplankton Community and Primary Production in the Caribbean Waters: the Biological Oceanography Component of the LAPE Project.* Barbados, 2007. ix + 88 pp., 8 Tables and 20 Figures, FI:GCP/RLA/140/JPN. Technical Document No. 5

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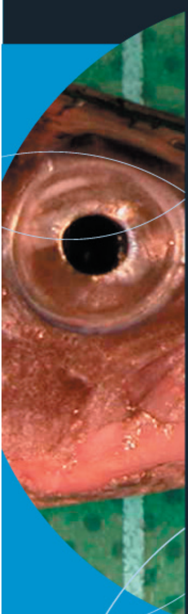
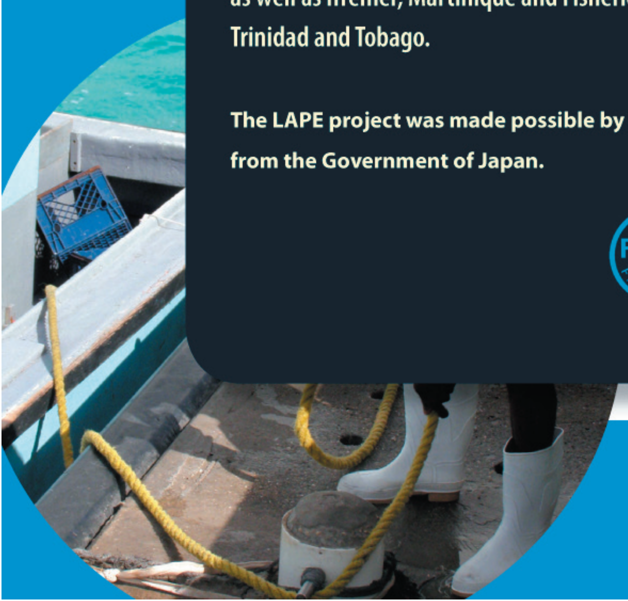
Mohammed; Elizabeth, Marcelo Vasconcellos; Steve Mackinson; Paul Fanning; Sherry Heileman and Fabio Carocci. *Scientific Basis For Ecosystem-Based Management In The Lesser Antilles Including Interactions With Marine Mammals And Other Top Predators: A Trophic Model Of The Lesser Antilles Pelagic Ecosystem.* FAO, Barbados, 2007. xi + 168 pp., 14 Tables and 27 Figures. FI:GCP/RLA/140/JPN. Technical Document No. 2





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